Zero Emission Vehicle Annual Report
Chevrolet S-10 Electric Pickup

Navy Environmental Leadership Program
Naval Air Station North Island
San Diego, California

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
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ZERO EMISSION VEHICLE ANNUAL REPORT

Navy Environmental Leadership Program

Chevrolet S-10 Electric Pickup

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1.0 INTRODUCTION

To reduce fuel consumption and air emissions—two major concerns at Navy bases—the Navy is increasingly turning to alternative-fuel vehicles. Naval Air Station (NAS) North Island is one of seven installations the Navy has designated to test the use of electric-powered zero emission vehicles (ZEV) as alternatives to the current gasoline- and diesel- powered fleet.

In support of the Navy Environmental Leadership Program (NELP), Tetra Tech EM Inc. (Tetra Tech) is evaluating ZEVs at NAS North Island. Currently, NAS North Island maintains a ZEV fleet consisting of 10 Chevrolet S-10 electric pickups, 3 electric vans, 5 electric carts, and more than 100 electric utility vehicles. This ZEV annual report provides a summary of the energy efficiency, operating and maintenance characteristics, and cost requirements of the 10 Chevrolet S-10 electric pickups at NAS North Island.

The electric pickups are being evaluated at NAS North Island under NELP in partnership with the Navy Facilities Engineering Service Center (NFESC). NFESC is coordinating the demonstrations at all seven Navy facilities, and has developed general guidance for data collection and reporting requirements for the electric vehicle evaluations.

The objective of this study was to assess the energy efficiency, operating and maintenance characteristics, and cost of fleet-operated electric vehicles. This objective was achieved by collecting monthly mileage and energy usage data from the electric vehicles and by surveying electric pickup users and reviewing maintenance records. This information provides quantitative data on the vehicle reliability and operating costs, and qualitative data on vehicle performance. For this study, data were collected from the period of September 1, 1997 through February 1, 1999.

This report summarizes the findings of the electric vehicle study conducted at NAS North Island. The report presents background information on the Navy's electric vehicle evaluation program, documents the data collection method and procedures, presents the evaluation results, discusses the data analysis and interpretation, and presents conclusions and recommendations based on the information obtained. The report focuses specifically on the 10 Chevrolet S-10 electric pickups because data on these vehicles are needed for the overall electric vehicle evaluation being conducted by NEFSC. The report will be updated on an annual basis.

2.0 BACKGROUND

This section presents background information on NELP, the NAS North Island electric vehicle program, the Chevrolet S-10 electric pickup truck, and the battery charging system.

2.1 NAVY ENVIRONMENTAL LEADERSHIP PROGRAM

NELP is an initiative established by the Secretary of the Navy to find new and better ways to manage the day-to-day efforts of the Navy's environmental programs. NELP's mission is to serve as a test bed for new and innovative technologies and to provide focused management to address the full spectrum of environmental issues. Successes from the program are exported throughout the Navy. NAS North Island in San Diego, California, and Naval Station Mayport in Florida were selected as NELP bases and are demonstrating innovative technologies and management approaches.

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NELP implementation at NAS North Island addresses four key elements of shore station environmental management: cleanup, compliance, natural resources and energy conservation, and pollution prevention. New projects are selected based on innovation, cost effectiveness, positive return on investment, and potential benefit to other Navy activities. The implementation approach establishes partnerships among NAS North Island personnel, the NELP management team, regulatory agencies, and the community.

2.2 NAS NORTH ISLAND ELECTRIC VEHICLE PROGRAM

In keeping with NELP's mission to accelerate cleanups and improve environmental management techniques, this ZEV study was initiated to evaluate the energy efficiency and operating characteristics of electric vehicles at NAS North Island. The Navy Public Works Center (PWC) San Diego began integrating zero emissions alternative-fueled-vehicles at NAS North Island in 1993 to comply with the goals of the Clean Air and Energy Policy Acts. In June 1997, gasoline-powered vehicles were replaced by electric pickups on a one-to-one basis at the following tenant activities at NAS North Island: Staff Civil Engineer (2 vehicles, EP-1 and EP-2), Aircraft Intermediate Maintenance Department (AIMD) Airframes, Operations Department, HS-10 Warhawks, Supply Department/Galley, Naval Aviation Depot (NADEP) Environmental Department, Commander Naval Base (COMNAVBASE) San Diego, PWC Zone 1, and PWC Transportation. In July 1997, one exterior inductive charging station was installed at each tenant activity that was assigned the vehicles. The electric pickups are used for interbase travel between NAS North Island, Naval Station (NAVSTA) San Diego, and COMNAVBASE San Diego.

2.3 CHEVROLET S-10 ELECTRIC PICKUP

The Chevrolet S-10 electric pickup, developed by General Motors (GM), is a two-seat electric vehicle used by the Navy for local transport of equipment and personnel. The front wheel drive vehicle weighs 4,300 pounds and has a maximum payload of 850 pounds. The vehicle is powered by a 114-horsepower electric engine, which runs on a 1,400-pound rechargeable battery pack. The battery pack is located under the bed of the truck and consists of 26 separate, maintenance-free lead-acid batteries. The Chevrolet S-10 also features regenerative braking: when coasting or braking, the regeneration system converts kinetic energy into electricity that returns to the battery pack, thereby extending the driving range of the vehicle. According to GM, the electric pickup has a range of 40 to 60 miles on a full charge. The more conservatively the vehicle is driven, the greater its range (the vehicle can cruise for approximately 60 miles at a constant speed of 45 miles per hour [mph] or for 40 miles in stop-and-go driving conditions) (Chevrolet 1996). Driving range will also be reduced by low tire pressure, low battery temperature, and use of auxiliary equipment such as the heater, air conditioner, and lights. The Chevrolet S-10 accelerates from 0 to 50 mph in 13.5 seconds at any state of charge from 100 percent to approximately 40 percent and has a top speed of 70 mph (Chevrolet 1996).

The Chevrolet S-10 electric pickup looks and operates like its gasoline-powered counterpart. The driver enters, buckles up, inserts the key into the switch, turns the key, puts the vehicle into drive, and drives off. However, internally the vehicle is much different from its gasoline counterpart. The internal components consist primarily of a battery pack, controller, and motor. These components have far fewer moving parts than the gasoline engine it replaces—no pistons, connecting rods, crankshaft, or cam shaft, for example.

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Additional information on the Chevrolet S-10 electric pickup truck can be obtained by calling the GM Alternative Fuel Vehicles Information Center at (888) 462-3848.

2.4 BATTERY CHARGING SYSTEM

At NAS North Island, eight outdoor, floor-mounted and two indoor, wall-mounted Delco Electronics 6.6 kilowatt (kW) charging stations were installed to recharge the Chevrolet S-10 electric pickup battery packs. The battery charger converts the alternating current distributed by electric utilities to direct current needed to recharge the battery. The Delco Electronics chargers use inductive coupling. This coupling uses a paddle that fits into a socket on the car. Rather than transferring the power by a direct wire connection, power is transferred by induction, in other words, by a magnetic coupling between the windings of two separate coils, one in the paddle, the other in the vehicle.

The time required to recharge the batteries depends on the total amount of energy that can be stored in the battery pack, and the voltage and current available from the battery charger. The charging time with the 6.6 kW unit is 2½ to 3 hours (from 15 to 95 percent state of charge) (Chevrolet 1996). The charger has a visual display that provides a running report of the battery pack's state of charge (0 to 100 percent) and approximately how much charging time will be required before the battery pack is fully charged.

It is not necessary to monitor the charging time. The user can insert the charging paddle in the pickup charge port and walk away. When charging is complete, the charger automatically shuts off. The driver can use the pickup at any time before it is fully charged by removing the paddle from the charge port, stowing it in the charger, and driving away (Chevrolet 1996).

Additional information on the Delco Electronics chargers installed at NAS North Island can be obtained by calling Edison EV, Inc. at (626) 334-8088.

2.5 ELECTRIC METER

For each charging, an E-CON Series, single phase, digital kilowatt hour meter was installed to monitor power to each individual charger after the utility company meter. The meters were housed in weather tight boxes, which were readily accessible for data collection. The number displayed in the 50 ampere meters was multiplied by four to obtain kilowatt hours. The meters were calibrated and tested at the factory before being packaged and shipped, and have a 5-year limited warranty.

3.0 METHODS AND PROCEDURES

This section describes the methods and procedures used to collect and analyze data for the ZEV evaluation. To meet the evaluation objectives, cumulative mileage and energy usage data on the electric vehicles were collected monthly and an annual user survey and maintenance record review were conducted. Tests to evaluate performance deterioration (range, acceleration, and recharge time) as recommended by NFESC were not conducted as part of this evaluation. All data collected for this study were recorded manually; automated data collection was not used to document operational characteristics of the electric vehicles.

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Monthly usage data were limited to mileage and energy use only. Cumulative mileage on the odometer of each vehicle and cumulative energy use from the electric meters installed with each charging station were recorded monthly. The mileage and energy data were plotted and graphed for each individual pickup and cumulatively for all 10 vehicles.

To assess the operation and maintenance characteristics of the electric vehicles, customer surveys provided by NFESC were used to gather user feedback and data on maintenance characteristics (NFESC 1997). The survey forms were modified to improve their clarity and ease of use. Each tenant activity operating an electric vehicle was contacted in advance to explain the purpose of the survey and to schedule a convenient time to conduct the survey. Three to four surveys were provided to each tenant activity.

Surveys were distributed to drivers of each of the electric pickups. The surveys were divided into four sections: user expectations, job applicability, interior comfort and gauges, and vehicle charging. Blank surveys are included in Appendix A. The responses to each of the 34 survey questions were scored on a 5-point Likert scale (Strongly Agree = 5, Agree = 4, Not Sure = 3, Disagree = 2, Strongly Disagree = 1). High scores indicate a positive response to the electric pickups. The numerical scores for each question, group of questions, and entire survey were averaged to assess overall satisfaction. Not applicable responses and questions left blank were not factored into the averages. The data were also graphed to visually depict the results of the survey.

Surveys were also conducted for compressed natural gas (CNG) and gasoline vehicles. These surveys were conducted on similar vehicles (pickup trucks) and among staff who also drive the electric pickups. This information allowed a comparison of the electric vehicles against a known baseline of different vehicles under similar use. This baseline comparison strengthens the analysis of the electric vehicles, especially when comparing qualitative performance factors.

Maintenance surveys were provided to PWC transportation. However, because the electric pickups are under warranty, all repairs (except routine maintenance such as rotating the tires and checking fluid levels) were provided by a manufacturer's representative at City Chevrolet in San Diego, California. Although maintenance surveys were not completed by PWC personnel, repair records were reviewed at City Chevrolet to evaluate maintenance requirements and reliability of the electric vehicles. The maintenance records review provided qualitative information on performance and quantitative information on reliability. In addition, vehicle and maintenance costs were documented.

4.0 RESULTS

This section presents the results of the electric vehicle evaluation at NAS North Island, including operating conditions, energy cost at NAS North Island, monthly mileage and energy usage, and user and maintenance survey results. The demonstration results have been supplemented by information provided by the vendor and the Navy.

4.1 VEHICLE OPERATING CONDITIONS

The Chevrolet S-10 electric pickup trucks are used for interbase travel between NAS North Island, NAVSTA, and COMNAVBASE. The pickups are used by multiple personnel primarily during daylight hours. The trip length varies among users; however, it is typically less than 30 miles round

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trip. Use of the vehicles varies considerably. Over a 16-month period, vehicle usage ranged from less than 80 miles per month to greater than 280 miles per month. During the same period, average vehicle usage was about 176 miles per month. In general, on-base travel is limited to speeds under 30 mph; however, during interbase travel speeds as high as 60 mph are necessary. The topography in the usage area is relatively flat with the exception of the Coronado Bridge, which must be crossed to travel from NAS North Island to NAVSTA and COMNAVBASE.

4.2 MONTHLY MILEAGE AND ENERGY RESULTS

Cumulative mileage and energy usage data were collected monthly for each vehicle and charging station from September 1998 through February 1999. In addition, data were collected for June 1998. A summary of the monthly mileage and energy usage data is presented in Table 4-1. A bar graph depicting cumulative monthly mileage and energy data for all 10 vehicles is provided as Figure 4-1. In addition, graphical plots of mileage and energy versus time for each vehicle are provided in Appendix B as Figures B-1 through B-11. From September 1997 to February 1, 1999, the 10 electric pickups logged a total of more than 30,000 miles and used an estimated 20,000 kilowatt-hours (kWh) of electricity. Mileage on each vehicle during this period ranged from 1,334 to 5,032 miles and averaged 3,020 miles per vehicle for the 10 vehicles. Energy use ranged from 1,036 to an estimated 3,400 kWh and averaged an estimated 2,045 kWh per vehicle for the 10 vehicles. Based on the data collected to date, efficiency of the vehicles (as measured by the miles per kWh [mi/kWh]) ranged from 1.11 to 1.87 mi/kWh and averaged 1.48 mi/kWh per vehicle for the 10 vehicles. The average mi/kWh calculated for the February 1, 1999 monthly event shows a decrease of about 0.17 mi/kWh from the high of 1.65 mi/kWh for the June 30, 1998 monthly event. Monthly mileage and energy usage results for each electric pickup are presented in Appendix C.

Energy usage data from the HS-10 Warhawk electric pickup were not available because of a malfunction in the electrical meter. Energy usage for the HS-10 Warhawk electric pickup was estimated based on the average miles per kWh calculated for the study. In addition, during the monthly data collection, several of the pickups were unavailable for mileage readings because they were at City Chevrolet for maintenance. In these instances, the vehicle mileage on the odometer was obtained verbally from City Chevrolet maintenance personnel.

4.3 USER SURVEYS

This section presents the results of the user surveys for the electric, CNG, and gasoline-powered pickups. The user surveys were conducted in December 1998. The electric vehicle user surveys consisted of 34 questions divided among the following four categories: (1) user expectations, (2) job applicability, (3) interior comfort and gauges, and (4) vehicle charging. User expectation questions focused on vehicle acceleration, braking, power, steering, stability, and ride. Job applicability questions evaluated the pickup's reliability, suitability, and adequacy, including range, payload

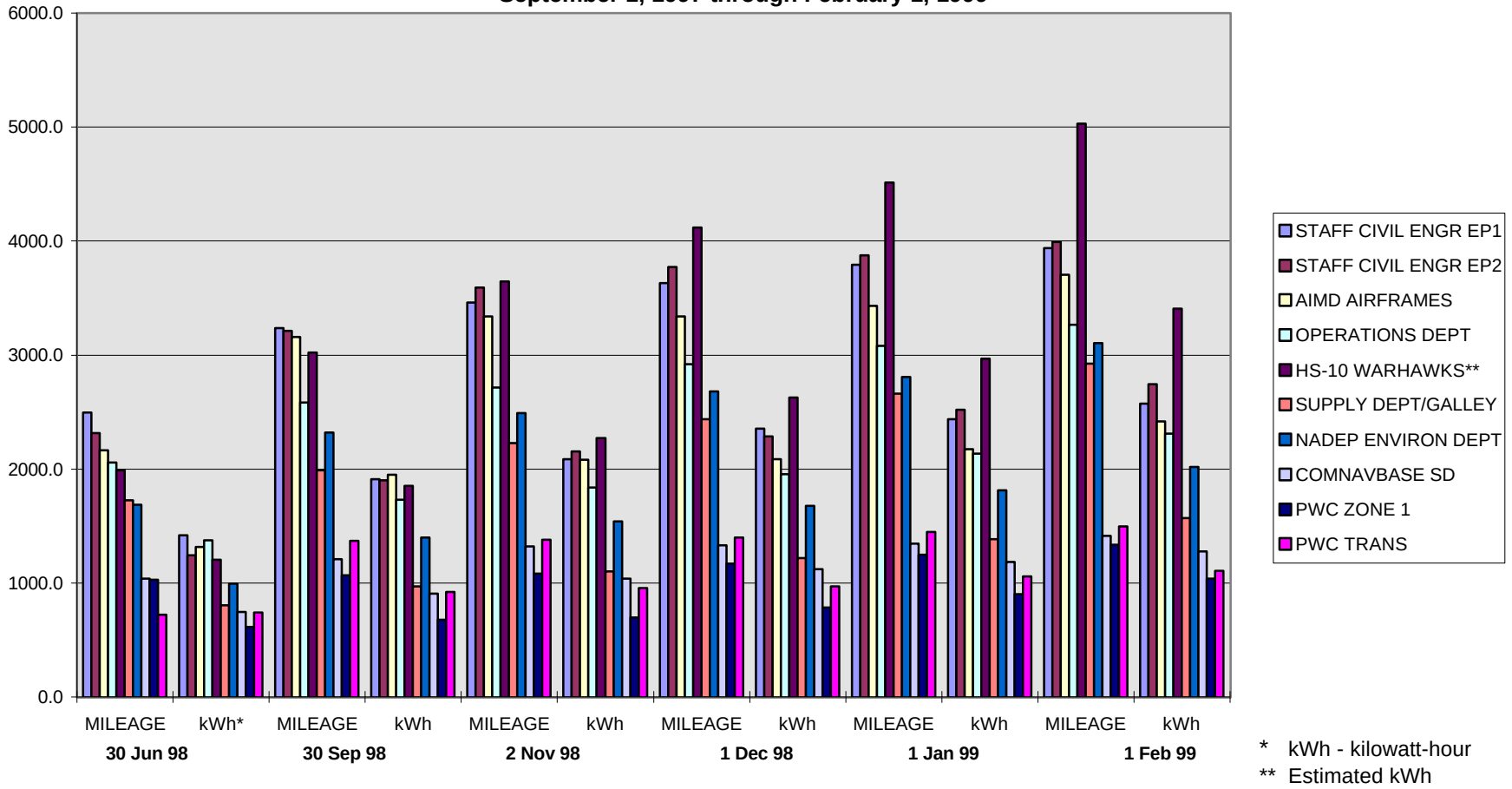
Table 4-1
Monthly Mileage and Energy Usage
June 30, 1998 through February 1, 1999

Vehicle	Dates					
STAFF CIVIL ENGINEER EP-1	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	2497	3238	3462	3629	3793	3938
kWh*	1420	1912	2084	2356	2436	2572
Miles/kWh	1.76	1.69	1.66	1.54	1.56	1.53
STAFF CIVIL ENGINEER EP-2	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	2317	3214	3591	3774	3874	3990
kWh	1244	1900	2156	2284	2520	2744
Miles/kWh	1.86	1.69	1.67	1.65	1.54	1.45
AIMD AIRFRAMES	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	2164	3158	3338	3338	3430	3704
kWh	1316	1948	2080	2084	2172	2416
Miles/kWh	1.64	1.62	1.60	1.60	1.58	1.53
OPERATIONS DEPARTMENT	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	2056	2584	2716	2919	3082	3264
kWh	1376	1732	1836	1956	2136	2312
Miles/kWh	1.49	1.49	1.48	1.49	1.44	1.41
HS-10 WARHAWKS**	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1989	3021	3644	4120	4511	5032
kWh**	1206	1853	2273	2627	2968	3407
Miles/kWh**	1.65	1.63	1.60	1.57	1.52	1.48
SUPPLY DEPARTMENT/GALLEY	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1725	1988	2229	2436	2662	2925
kilowatt-hours	804	968	1100	1220	1384	1568
Miles/kWh	2.15	2.05	2.03	2.00	1.92	1.87
NADEP ENVIRONMENTAL DEPARTMENT	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1685	2319	2489	2679	2809	3106
kWh	996	1400	1540	1676	1812	2016
Miles/kWh	1.69	1.66	1.62	1.60	1.55	1.54
COMNAVBASE SAN DIEGO	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1037	1211	1319	1333	1344	1413
kWh	748	908	1036	1120	1184	1276
Miles/kWh	1.39	1.33	1.27	1.19	1.14	1.11
PWC ZONE 1	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1030	1067	1084	1168	1250	1334
kWh	616	676	696	784	900	1036
Miles/kWh	1.67	1.58	1.56	1.49	1.39	1.29
PWC TRANSPORTATION	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	721	1370	1382	1398	1448	1497
kWh	740	920	956	972	1060	1108
Miles/kWh	0.97	1.49	1.45	1.44	1.37	1.35
TOTALS	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	17222	23169	25254	26793	28203	30203
kWh	10466	14217	15757	17079	18572	20455
AVERAGES	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
MILEAGE	1722	2317	2525	2679	2820	3020
kWh	1047	1422	1576	1708	1857	2046
TOTALS	**Jun-98**	**Sep-98**	**Nov-98**	**Dec-98**	**Jan-99**	**Feb-99**
Miles/kWh	1.65	1.63	1.60	1.57	1.52	1.48

* kilowatt-hours

** kWh meter malfunctioning - energy use values estimated

Figure 4-1
Cumulative Monthly Mileage and Energy Usage
September 1, 1997 through February 1, 1999



* kWh - kilowatt-hour
** Estimated kWh

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capacity, and maneuverability. Interior comfort and gauges questions assessed the accuracy of gauges, noise level in vehicle, and adequacy of the heater, defroster, and air conditioner. Charging questions assessed the ease of charging. The CNG and gasoline vehicle user surveys consisted of 31 and 28 questions, respectively, which were divided among the first three categories used in the electric vehicle survey. The CNG and gasoline surveys did not include questions pertaining to charging. The scoring for questions 18 and 28 on the ZEV survey and 19 and 29 on the CNG and gasoline surveys was reversed for consistency with the other questions. High scores are designed to correlate with high satisfaction. The results of the user surveys for the electric, CNG, and gasoline-powered pickups are summarized in Tables 4-2, 4-3, and 4-4. The individual surveys for the electric-, CNG-, and gasoline-powered vehicles are available upon request.

Twenty-four surveys were received from users of the 10 electric pickups. The average response to each electric pickup user survey ranged from 3.6 to 4.6 with an overall average of 4.0 for all 24 users surveyed. The overall average response to the CNG and gasoline surveys was 3.5 and 3.6, respectively. Survey results for each electric pickup are presented in Appendix C.

Six surveys were received from users of CNG powered pickups. The average response to the user survey ranged from 3.3 to 3.8 with an overall average of 3.5 for six users surveyed. Thirteen surveys were received from users of gasoline-powered pickups. The average response to the user survey ranged from 2.5 to 4.7 with an overall averaged 3.6 for all 13 users surveyed. A summary of the average survey results for the electric, CNG, and gasoline-powered pickups is provided in Table 4-5 and is graphically depicted on Figure 4-2. A summary of the survey results for the individual electric pickups compared to the average CNG- and gasoline-powered vehicle user responses for each of the four survey categories is presented in Appendix C as Figures C-1 through C-4.

4.4 MAINTENANCE RECORDS REVIEW

Maintenance problems with the Chevrolet S-10 electric pickups are brought to the attention of the PWC Transportation maintenance department at NAS North Island, which has two mechanics trained to handle routine problems and to inspect the electric vehicles. Routine maintenance and inspection typically occurs once every 7,500 miles and requires about 1/2 hour to complete (Tetra Tech 1999a).

However, because the vehicles have been sent for repair at City Chevrolet frequently, PWC Transportation has not conducted routine maintenance of the electric pickups to date. During routine maintenance and inspection, the tire pressure is checked, the tires are rotated, and all fluid levels are inspected. A loaner electric vehicle is available from PWC for use while the vehicle is in the shop.

When nonroutine problems are encountered, PWC takes the vehicle to City Chevrolet in San Diego, where the vehicles are serviced under warranty. A summary of the maintenance records reviewed at City Chevrolet, including information on the frequency of specific repairs and the time required to complete the repairs is presented in Table 4-6. A summary of the maintenance conducted on the electric pickups, including the date the vehicle was serviced, the maintenance problem encountered, the repairs completed, and cost of the repairs is presented in Appendix C as Table C-1. Based on the maintenance data, the majority of maintenance problems (52 out of 66) were related to four items: (1) battery/charging, (2) coolant leaking/bad seal, (3) axle replacement, and (4) inoperable power steering.

Table 4-2
Electric Powered Vehicle Survey Results

	AIMD (Averitt)	AIMD (Ptacnik)	AIMD	AIMD (Looker)	**AIMD Summary**	HS-10 (Oliveros)	HS-10 (Parker	HS-10 (Anteachman)	**HS-10 Summary**	NADEP (Beyer)	NADEP (Doury)	NADEP (Pfeiffer)	NADEP (Holzer)	**NADEP Summary**	Supply (Belbin)	Supply (Grizzard)	Supply (Smith)	Supply (Jackson)	**Supply Summary**	Operations	Operations	Operations	Operations	**Operations Summary**	PWC Zone 1	**PWC Zone 1 Summary**	COMNAVBASE	**COMNAVNBASE Summary**	SCE (Rogers)	SCE	**SCE Summary**	PWC Transportation (Lewis)	**PWC Transportation Summary**	**Average**
Expectations																																	
1. Vehicle's overall acceleration is adequate.	5	4	4	4	**4.3**	4	5	4	**4.3**	4	5	4	5	**4.5**	4	4	4	5	**4.3**	5	5	5	5	**5.0**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.5**
2. Vehicle accelerates like a gasoline vehicle.	4	4	4	4	**4.0**	4	5	4	**4.3**	4	4	4	4	**4.0**	5	2	1	5	**3.3**	4	4	4	5	**4.3**	2	**2.0**	2	**2.0**	4	4	**4.0**	5	**5.0**	**3.8**
3. Vehicle accelerates well when cold (first start-up).	5	4	4	4	**4.3**	2	5	4	**3.7**	4	5	3	NA	**4.0**	4	3	3	5	**3.8**	4	4	5	4	**4.3**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.1**
4. Vehicle accelerates well when hot.	5	4	4	4	**4.3**	4	5	4	**4.3**	4	5	3	3	**3.8**	4	3	3	5	**3.8**	5	4	5	5	**4.8**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.2**
5. Vehicle's overall braking adequate.	4	4	4	4	**4.0**	2	4	4	**3.3**	3	5	4	5	**4.3**	4	2	2	5	**3.3**	5	5	4	4	**4.5**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.0**
6. Vehicle's brakes operate like a gasoline work vehicle.	4	4	4	4	**4.0**	4	4	4	**4.0**	4	5	2	5	**4.0**	4	2	2	5	**3.3**	5	5	5	4	**4.8**	3	**3.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.0**
7. Vehicle brakes well with cold brakes (limited use).	4	4	4	4	**4.0**	2	4	4	**3.3**	4	5	3	5	**4.3**	4	3	3	5	**3.8**	5	4	4	4	**4.3**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.0**
8. Vehicle brakes well with hot brakes (heavy use).	4	4	4	4	**4.0**	2	4	4	**3.3**	4	5	3	5	**4.3**	4	3	3	5	**3.8**	4	5	5	5	**4.8**	4	**4.0**	3	**3.0**	4	4	**4.0**	5	**5.0**	**4.0**
9. Vehicle's power (up hills/heavy load) adequate.	NA	NA	3	3	**3.0**	4	5	4	**4.3**	4	3	3	5	**3.8**	4	NA	NA	4	**4.0**	5	5	4	5	**4.8**	4	**4.0**	3	**3.0**	3	4	**3.5**	5	**5.0**	**4.0**
10. Vehicle's power is similar to a gasoline vehicle.	2	2	4	2	**2.5**	4	5	4	**4.3**	4	2	4	4	**3.5**	4	3	3	5	**3.8**	4	5	5	4	**4.5**	4	**4.0**	2	**2.0**	2	4	**3.0**	5	**5.0**	**3.6**
11. Vehicle's steering is responsive.	4	4	4	4	**4.0**	5	5	4	**4.7**	4	4	5	5	**4.5**	4	4	4	4	**4.0**	5	4	4	5	**4.5**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.3**
12. Vehicle maneuvers like a gasoline vehicle.	4	4	4	4	**4.0**	5	5	4	**4.7**	4	4	4	4	**4.0**	4	2	2	4	**3.0**	5	5	5	4	**4.8**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.1**
13. Vehicle is stable at highway speeds.	4	4	4	4	**4.0**	4	5	4	**4.3**	NA	3	4	5	**4.0**	4	NA	NA	4	**4.0**	5	5	4	4	**4.5**	4	**4.0**	5	**5.0**	3	NA	**3.0**	5	**5.0**	**4.2**
14. Vehicle is stable in wet/icy weather.	NA	3	3	4	**3.3**	4	3	4	**3.7**	NA	3	3	NA	**3.0**	4	4	4	4	**4.0**	4	5	5	5	**4.8**	4	**4.0**	5	**5.0**	NA	3	**3.0**	5	**5.0**	**4.0**
15. Vehicle rides like a gasoline vehicle.	4	4	4	4	**4.0**	2	5	4	**3.7**	4	2	4	5	**3.8**	4	4	4	4	**4.0**	5	4	5	5	**4.8**	2	**2.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.0**
16. Vehicle cruises at constant speeds well.	4	4	4	4	**4.0**	4	5	4	**4.3**	4	3	4	5	**4.0**	4	NA	NA	4	**4.0**	5	4	5	5	**4.8**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.2**
17. Vehicle's operating noise is acceptable.	5	4	4	4	**4.3**	NA	5	4	**4.5**	4	5	5	5	**4.8**	4	4	4	1	**3.3**	5	4	5	4	**4.5**	4	**4.0**	4	**4.0**	3	4	**3.5**	5	**5.0**	**4.2**
18. Vehicle is more quiet than a gasoline vehicle.	5	4	4	4	**4.3**	5	5	4	**4.7**	4	5	5	5	**4.8**	5	5	5	1	**4.0**	5	5	5	5	**5.0**	4	**4.0**	5	**5.0**	4	4	**4.0**	5	**5.0**	**4.5**
19. Vehicle is louder than a gasoline vehicle.[a]	5	4	4	4	**4.3**	4	5	4	**4.3**	4	5	5	5	**4.8**	5	5	5	1	**4.0**	5	5	5	4	**4.8**	4	**4.0**	5	**5.0**	2	5	**3.5**	5	**5.0**	**4.4**
Average	**4.2**	**3.8**	**3.9**	**3.8**	4.0	**3.6**	**4.7**	**4.0**	4.1	**3.9**	**4.1**	**3.8**	**4.7**	4.1	**4.2**	**3.3**	**3.3**	**4.0**	3.7	**4.7**	**4.6**	**4.7**	**4.5**	4.6	**3.7**	3.7	**4.2**	4.2	**3.6**	**4.0**	3.8	**5.0**	5.0	4.1
Job Applicability																																	
20. Vehicle is suited for your job application.	4	4	4	5	**4.3**	2	5	4	**3.7**	4	5	4	5	**4.5**	4	5	5	5	**4.8**	5	4	4	4	**4.3**	2	**2.0**	4	**4.0**	4	4	**4.0**	3	**3.0**	**4.1**
21. The vehicle's range is adequate for your job.	4	4	5	4	**4.3**	2	4	4	**3.3**	1	1	4	5	**2.8**	4	5	5	4	**4.5**	5	4	4	4	**4.3**	4	**4.0**	3	**3.0**	2	4	**3.0**	1	**1.0**	**3.6**
22. The vehicle's payload capacity is adequate for your job.	4	4	4	4	**4.0**	2	5	4	**3.7**	4	5	4	5	**4.5**	4	5	5	4	**4.5**	5	4	4	4	**4.3**	4	**4.0**	4	**4.0**	4	4	**4.0**	1	**1.0**	**4.0**
23. The vehicle's power is adequate for your job.	4	4	4	4	**4.0**	4	5	4	**4.3**	4	5	4	5	**4.5**	4	5	5	4	**4.5**	4	5	5	5	**4.8**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.4**
24. The vehicle's maneuverability is adequate.	4	4	4	4	**4.0**	4	5	4	**4.3**	4	5	4	5	**4.5**	4	5	5	4	**4.5**	4	5	5	5	**4.8**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.4**
25. The vehicle has been reliable.	2	2	4	2	**2.5**	2	4	4	**3.3**	4	2	2	5	**3.3**	2	1	1	2	**1.5**	4	4	4	5	**4.3**	1	**1.0**	2	**2.0**	4	4	**4.0**	1	**1.0**	**2.8**
Average	**3.7**	**3.7**	**4.2**	**3.8**	3.8	**2.7**	**4.7**	**4.0**	3.8	**3.5**	**3.8**	**3.7**	**5.0**	4.0	**3.7**	**4.3**	**4.3**	**3.8**	4.0	**4.5**	**4.3**	**4.3**	**4.5**	4.4	**3.2**	3.2	**3.5**	3.5	**3.7**	**4.0**	3.8	**2.7**	2.7	3.9
Interior Comfort and Gauges																																	
26. The battery state of charge gauge is accurate.	3	3	3	3	**3.0**	4	4	4	**4.0**	4	3	4	4	**3.8**	4	NA	NA	4	**4.0**	4	4	4	4	**4.0**	2	**2.0**	4	**4.0**	4	4	**4.0**	4	**4.0**	**3.7**
27. The battery energy conservation is gauge accurate.	3	3	3	3	**3.0**	3	3	4	**3.3**	4	3	4	3	**3.5**	4	NA	NA	4	**4.0**	4	4	4	4	**4.0**	3	**3.0**	3	**3.0**	4	4	**4.0**	4	**4.0**	**3.5**
28. The vehicle is more quiet inside than a gasoline vehicle.	4	4	4	4	**4.0**	5	5	4	**4.7**	4	5	5	5	**4.8**	4	5	5	1	**3.8**	5	5	4	5	**4.8**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.3**
29. The vehicle is louder inside than a gasoline vehicle.[a]	4	5	4	4	**4.3**	4	5	4	**4.3**	4	5	5	5	**4.8**	5	5	5	1	**4.0**	5	4	5	4	**4.5**	4	**4.0**	4	**4.0**	4	5	**4.5**	5	**5.0**	**4.4**
30. The heater provides adequate heat.	4	4	4	4	**4.0**	5	NA	4	**4.5**	4	3	4	3	**3.5**	3	NA	NA	1	**2.0**	4	4	4	4	**4.0**	4	**4.0**	3	**3.0**	4	4	**4.0**	2	**2.0**	**3.6**
31. The defroster works adequately (within 10 min.).	4	4	4	3	**3.8**	5	4	4	**4.3**	4	3	3	NA	**3.3**	3	NA	NA	1	**2.0**	4	4	4	4	**4.0**	4	**4.0**	4	**4.0**	3	4	**3.5**	2	**2.0**	**3.6**
32. The A/C provides adequate cooling.	4	4	4	3	**3.8**	5	2	4	**3.7**	3	2	2	4	**2.8**	2	4	4	2	**3.0**	4	4	4	4	**4.0**	4	**4.0**	4	**4.0**	4	4	**4.0**	1	**1.0**	**3.4**
Average	**3.7**	**3.9**	**3.7**	**3.4**	3.7	**4.4**	**3.8**	**4.0**	4.1	**3.9**	**3.4**	**3.9**	**4.0**	3.8	**3.6**	**4.7**	**4.7**	**2.0**	3.7	**4.3**	**4.1**	**4.1**	**4.1**	4.2	**3.6**	3.6	**3.7**	3.7	**3.9**	**4.1**	4.0	**3.3**	3.3	3.8
Charging																																	
33. The vehicle charges fully overnight.	5	4	4	3	**4.0**	5	5	4	**4.7**	3	3	4	5	**3.8**	4	NA	NA	5	**4.5**	4	4	4	4	**4.0**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.1**
34. The charging connections are easily made.	3	4	4	4	**3.8**	5	5	4	**4.7**	4	5	4	5	**4.5**	4	NA	NA	5	**4.5**	5	5	4	4	**4.5**	4	**4.0**	4	**4.0**	4	4	**4.0**	5	**5.0**	**4.3**
Average	**4.0**	**4.0**	**4.0**	**3.5**	3.9	**5.0**	**5.0**	**4.0**	4.7	**3.5**	**4.0**	**4.0**	**5.0**	4.1	**4.0**	**NA**	**NA**	**5.0**	4.5	**4.5**	**4.5**	**4.0**	**4.0**	4.3	**4.0**	4.0	**4.0**	4.0	**4.0**	**4.0**	4.0	**5.0**	5.0	4.2
Total Average	**4.0**	**3.8**	**3.9**	**3.7**	3.8	**3.7**	**4.5**	**4.0**	4.1	**3.8**	**3.9**	**3.8**	**4.6**	4.0	**3.9**	**3.7**	**3.7**	**3.6**	3.7	**4.6**	**4.4**	**4.5**	**4.4**	4.5	**3.6**	3.6	**3.9**	3.9	**3.7**	**4.0**	3.8	**4.2**	4.2	4.0

Notes:

a. The scoring on these questions was reversed for consistency.

Strongly Agree = 5 -- Agree = 4 -- Not Sure = 3 -- Diagree = 2 -- Strongly Disagree = 1

Table 4-3
CNG Powered Vehicle Survey Results

	SCE	SCE Summary	PWC Zone 1	PWC Zone 1 Summary	AIMD	AIMD	AIMD	AIMD	AIMD Summary	Average
Expectations										
1. Vehicle's overall acceleration is adequate.	2	**2.0**	4	**4.0**	4	4	4	4	**4.0**	**3.7**
2. Vehicle accelerates like a gasoline vehicle.	1	**1.0**	4	**4.0**	2	2	4	4	**3.0**	**2.8**
3. Vehicle accelerates well when cold (first start-up).	1	**1.0**	4	**4.0**	4	4	3	3	**3.5**	**3.2**
4. Vehicle accelerates well when hot.	1	**1.0**	4	**4.0**	3	3	4	4	**3.5**	**3.2**
5. Vehicle's overall braking adequate.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
6. Vehicle's brakes operate like a gasoline work vehicle.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
7. Vehicle brakes well with cold brakes (limited use).	4	**4.0**	4	**4.0**	4	4	3	3	**3.5**	**3.7**
8. Vehicle brakes well with hot brakes (heavy use).	4	**4.0**	4	**4.0**	4	4	3	3	**3.5**	**3.7**
9. Vehicle's power (up hills/heavy load) adequate.	1	**1.0**	4	**4.0**	4	2	2	2	**2.5**	**2.5**
10. Vehicle's power is similar to a gasoline vehicle.	1	**1.0**	4	**4.0**	2	2	2	2	**2.0**	**2.2**
11. Vehicle's steering is responsive.	4	**4.0**	4	**4.0**	2	4	4	4	**3.5**	**3.7**
12. Vehicle maneuvers like a gasoline vehicle.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
13. Vehicle is stable at highway speeds.	4	**4.0**	3	**3.0**	4	4	3	3	**3.5**	**3.5**
14. Vehicle is stable in wet/icy weather.	NA	**NA**	4	**4.0**	NA	NA	3	3	**3.0**	**3.3**
15. Vehicle rides like a gasoline vehicle.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
16. Vehicle cruises at constant speeds well.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
17. Vehicle's operating noise is acceptable.	4	**4.0**	3	**3.0**	4	4	4	4	**4.0**	**3.8**
18. Vehicle is more quiet than a gasoline vehicle.	3	**3.0**	3	**3.0**	2	2	3	3	**2.5**	**2.7**
19. Vehicle is louder than a gasoline vehicle.	3	**3.0**	4	**4.0**	3	3	3	3	**3.0**	**3.2**
Average	**2.9**	**2.9**	**3.8**	**3.8**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**	**3.4**
Job Applicability										
20. Vehicle is suited for your job application.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
21. The vehicle's range is adequate for your job.	4	**4.0**	4	**4.0**	2	2	4	4	**3.0**	**3.3**
22. The vehicle's payload capacity is adequate for your job.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
23. The vehicle's power is adequate for your job.	4	**4.0**	4	**4.0**	3	3	4	4	**3.5**	**3.7**
24. The vehicle's maneuverability is adequate.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
25. The vehicle has been reliable.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
Average	**4.0**	**4.0**	**4.0**	**4.0**	**3.5**	**3.5**	**4.0**	**4.0**	**3.8**	**3.8**
Interior Comfort and Gauges										
26. The CNG gauge is accurate.	4	**4.0**	4	**4.0**	4	4	2	2	**3.0**	**3.3**
27. The vehicle is more quiet inside than a gasoline vehicle.	2	**2.0**	3	**3.0**	2	2	3	3	**2.5**	**2.5**
29. The vehicle is louder inside than a gasoline vehicle.	4	**4.0**	4	**4.0**	3	3	3	3	**3.0**	**3.3**
30. The heater provides adequate heat.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
31. The defroster works adequately (within 10 min.).	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
32. The A/C provides adequate cooling.	4	**4.0**	4	**4.0**	4	4	4	4	**4.0**	**4.0**
Average	**3.7**	**3.7**	**3.8**	**3.8**	**3.5**	**3.5**	**3.3**	**3.3**	**3.4**	**3.5**
Total Average	**3.3**	**3.3**	**3.8**	**3.8**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**	**3.5**

Strongly Agree = 5 -- Agree = 4 -- Not Sure = 3 -- Diagree = 2 -- Strongly Disagree = 1

Table 4-4
Gasoline Powered Vehicle Survey Results

	AIMD (Averitt)	AIMD (Pasco)	AIMD (Harrha)	AIMD (Looker)	**AIMD Summary**	HS-10 (Oliveros)	HS-10 (Anteachman)	HS-10 (Parker)	HS-10 (McDonald)	**HS-10 Summary**	Supply (Belbin)	Supply (Grizzard)	Supply (Smith)	Supply (Jackson)	**Supply Summary**	PWC (Zone 1)	**PWC Zone 1 Summary**	**Average**
Expectations																		
1. Vehicle's overall acceleration is adequate.	1	1	4	1	**1.8**	4	4	4	4	**4.0**	4	4	4	4	**4.0**	5	**5.0**	**3.4**
3. Vehicle accelerates well when cold (first start-up).	2	1	4	1	**2.0**	4	4	2	NA	**3.3**	4	3	3	4	**3.5**	4	**4.0**	**3.0**
4. Vehicle accelerates well when hot.	2	2	4	2	**2.5**	2	4	4	NA	**3.3**	4	4	4	4	**4.0**	5	**5.0**	**3.4**
5. Vehicle's overall braking adequate.	2	2	4	2	**2.5**	4	4	4	4	**4.0**	4	4	4	4	**4.0**	5	**5.0**	**3.6**
7. Vehicle brakes well with cold brakes (limited use).	3	3	4	3	**3.3**	2	4	4	4	**3.5**	4	3	3	4	**3.5**	5	**5.0**	**3.5**
8. Vehicle brakes well with hot brakes (heavy use).	3	3	4	3	**3.3**	4	4	4	4	**4.0**	4	3	3	4	**3.5**	5	**5.0**	**3.7**
9. Vehicle's power (up hills/heavy load) adequate.	1	1	4	1	**1.8**	2	4	4	4	**3.5**	4	NA	NA	4	**4.0**	5	**5.0**	**3.1**
10. Vehicle's power is good.	1	1	4	1	**1.8**	2	4	4	4	**3.5**	5	4	4	4	**4.3**	5	**5.0**	**3.3**
11. Vehicle's steering is responsive.	4	4	3	4	**3.8**	4	4	4	2	**3.5**	4	4	4	4	**4.0**	5	**5.0**	**3.8**
12. Vehicle maneuvers well.	4	4	4	4	**4.0**	4	4	3	NA	**3.7**	4	4	4	4	**4.0**	5	**5.0**	**4.0**
13. Vehicle is stable at highway speeds.	1	1	3	2	**1.8**	5	4	4	4	**4.3**	4	NA	NA	3	**3.5**	5	**5.0**	**3.3**
14. Vehicle is stable in wet/icy weather.	2	3	3	3	**2.8**	5	4	4	4	**4.3**	4	4	4	3	**3.8**	5	**5.0**	**3.7**
15. Vehicle rides smoothly.	1	2	4	1	**2.0**	4	4	4	4	**4.0**	4	2	2	4	**3.0**	5	**5.0**	**3.2**
16. Vehicle cruises at constant speeds well.	1	1	4	1	**1.8**	4	4	4	4	**4.0**	4	4	4	4	**4.0**	5	**5.0**	**3.4**
17. Vehicle's operating noise is acceptable.	2	4	4	4	**3.5**	2	4	4	4	**3.5**	4	4	4	4	**4.0**	5	**5.0**	**3.8**
Average	**2.0**	**2.2**	**3.8**	**2.2**	**2.6**	**3.5**	**4.0**	**3.8**	**3.8**	**3.8**	**4.1**	**3.6**	**3.6**	**3.9**	**3.8**	**4.9**	**4.9**	**3.5**
Job Applicability																		
18. Vehicle is suited for your job application.	4	4	4	4	**4.0**	2	4	4	4	**3.5**	4	5	5	4	**4.5**	5	**5.0**	**4.1**
19. The vehicle's range is adequate for your job.	4	4	4	4	**4.0**	2	4	4	4	**3.5**	4	5	5	5	**4.8**	5	**5.0**	**4.2**
20. The vehicle's payload capacity is adequate for your job.	4	2	4	2	**3.0**	2	4	4	4	**3.5**	4	5	5	5	**4.8**	5	**5.0**	**3.8**
21. The vehicle's power is adequate for your job.	1	1	4	2	**2.0**	4	4	4	4	**4.0**	4	5	5	5	**4.8**	5	**5.0**	**3.7**
22. The vehicle's maneuverability is adequate.	4	4	4	4	**4.0**	4	4	4	4	**4.0**	4	5	5	4	**4.5**	5	**5.0**	**4.2**
23. The vehicle has been reliable.	5	4	4	4	**4.3**	2	4	4	2	**3.0**	4	5	5	4	**4.5**	5	**5.0**	**4.0**
Average	**3.7**	**3.2**	**4.0**	**3.3**	**3.5**	**2.7**	**4.0**	**4.0**	**3.7**	**3.6**	**4.0**	**5.0**	**5.0**	**4.5**	**4.6**	**5.0**	**5.0**	**4.0**
Interior Comfort and Gauges																		
26. The fuel gauge is accurate.	4	3	NA	3	**3.3**	4	4	4	4	**4.0**	4	4	4	4	**4.0**	4	**4.0**	**3.8**
27. The vehicle is quiet inside.	1	2	4	2	**2.3**	3	4	4	4	**3.8**	4	1	1	4	**2.5**	4	**4.0**	**2.9**
29. The vehicle is loud inside.	2	2	NA	2	**2.0**	1	NA	NA	NA	**1.0**	2	2	2	2	**2.0**	3	**3.0**	**2.0**
30. The heater provides adequate heat.	NA	NA	NA	NA	**NA**	4	NA	NA	NA	**4.0**	5	4	4	4	**4.3**	4	**4.0**	**4.2**
31. The defroster works adequately (within 10 min.).	NA	NA	NA	NA	**NA**	5	NA	NA	NA	**5.0**	4	NA	NA	4	**4.0**	4	**4.0**	**4.3**
32. The A/C provides adequate cooling.	NA	NA	NA	NA	**NA**	5	NA	NA	NA	**5.0**	4	4	4	3	**3.8**	4	**4.0**	**4.0**
Average	**2.3**	**2.3**	**4.0**	**2.3**	**2.5**	**3.7**	**4.0**	**4.0**	**4.0**	**3.8**	**3.8**	**3.0**	**3.0**	**3.5**	**3.4**	**3.8**	**3.8**	**3.4**
Total Average	**2.5**	**2.5**	**3.9**	**2.5**	**2.8**	**3.3**	**4.0**	**3.9**	**3.8**	**3.8**	**4.0**	**3.8**	**3.8**	**3.9**	**3.9**	**4.7**	**4.7**	**3.6**

Note: Questions 2 and 6 were not relevant to gasoline powered vehicles and were therefore removed. Questions 24 and 25 were not asked in the survey.

Strongly Agree = 5 -- Agree = 4 -- Not Sure = 3 -- Diagree = 2 -- Strongly Disagree = 1

Figure 4-2
Survey Results Summary

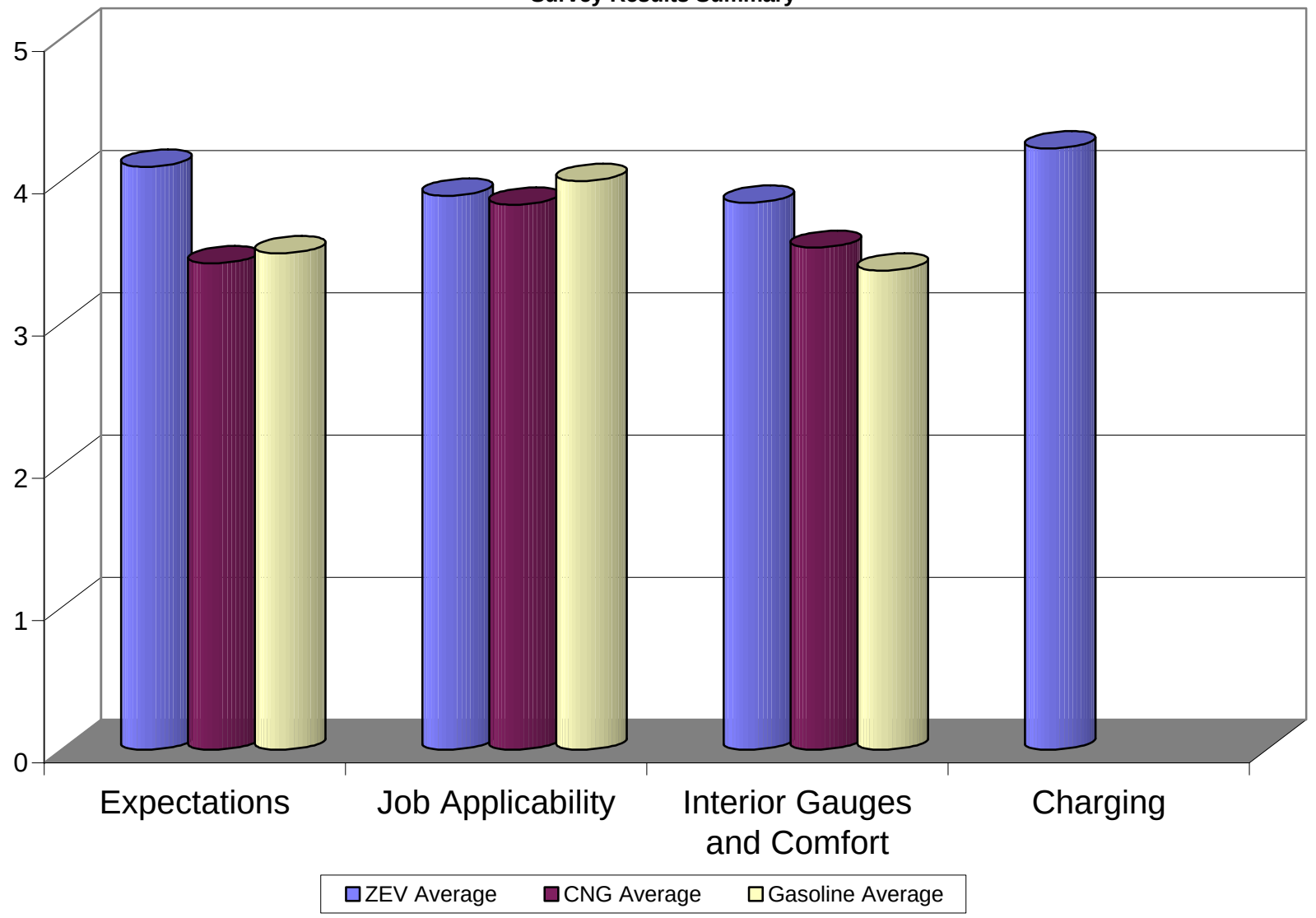

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TABLE 4-5

User Survey Summary
NAS North Island ZEV Evaluation

Type of Vehicle	Average Survey Response				
	Expectations	Job Applicability	Interior Comfort and Gauges	Charging	Overall
Electric	4.1	3.9	3.8	4.2	4.0
CNG	3.4	3.8	3.5	NA	3.5
Gasoline	3.5	4.0	3.4	NA	3.6

NA Not applicable

Of these documented problems, the most common was associated with the battery/charging system. Because all the electric pickups are under warranty, costs associated with the repairs were paid by the manufacturer.

From the period of September 10, 1997, through November 18, 1998, the 10 electric pickups were at City Chevrolet for repair 41 separate times. The repairs required a total of 720 days to complete, an average of 17.5 days per vehicle per repair. The time required to complete all repairs on each electric pickup ranged from 10 to 145 days with an average of 72 days per vehicle. The results of the maintenance records review for each electric pickup are presented in Appendix C.

5.0 INTERPRETATION AND DISCUSSION

This section interprets and discusses the monthly usage data, operating characteristics, maintenance characteristics, and cost analysis of fleet operated electric vehicles at NAS North Island.

5.1 MONTHLY USAGE DATA

Although some monthly variations in individual vehicle usage were observed, individual vehicle usage trends overall remained relatively unchanged from July 1998 through February 1, 1999. Observed changes in vehicle usage appear to be directly related to maintenance, when the vehicle was not available. These periods are shown on the individual vehicle mileage and energy usage versus time plots in Appendix B as a decrease in the slope of the mileage and energy trend lines.

Review of cumulative mileage and energy usage for each vehicle from September 1, 1997 through February 1, 1999, indicated that vehicle usage varied for each electric pickup. Of the 10 electric pickups, three were driven less than 1,500 miles. The other seven were driven more than 3,000 miles with the exception of the Supply Department electric pickup, which was driven 2,925 miles. The pickups operated by COMNAVBASE, PWC Zone 1, and PWC Transportation were all driven less than 1,500 miles. Users of the three-low mileage vehicles viewed the electric pickup as having lower job applicability, especially with regard to vehicle reliability, than did the high-mileage vehicle users.

Table 4-6
Maintenance Frequency and Duration Summary

Vehicle ID	Battery/charging problems	Coolant leaking/bad seal	Campaign (replaced axles)	P/S Inoperable	Heater not working	Updates	Electrolyte reservoir empty	Charge recepticle overheat	Shudders/rough acceleration	Auxiliary battery problems	Body work
AIMD: 94-62890 (V8191050) - 59 Service Days											
11-Feb-98		●	●		●						
20-Apr-98	●										
21-Oct-98	●				●						
NADEP: 94-62896 (V8199171) - 10 Service Days											
09-Dec-97	●	●									
01-Apr-98	●	●	●								
23-Sep-98						●					
PWC Zone 1: 94-62897 (V8198651) - 145 Service Days											
10-Sep-97	●										
26-Feb-98			●								
14-May-98	●										
04-Aug-98	●										
SCE EP1: 94-62892 (V8192876) - 84 Service Days											
10-Sep-97	●										
17-Nov-97	●						●				
11-Feb-98	●		●					●			
04-Aug-98	●	●									
24-Sep-98	●	●			●						
SCE EP2: 94-62893 (V8193021) - 83 Service Days											
10-Sep-97				●							
06-Feb-98	●		●								
10-Jul-98	●			●							
24-Sep-98	●				●						
SUPPLY: 94-62894 (V8192839) - 87 Service Days											
24-Sep-97				●							
22-Oct-97	●			●							
30-Jun-98	●		●								
04-Aug-98	●										
09-Sep-98	●										
24-Sep-98	●				●						
OPERATIONS: 94-62891 (V8194074) - 10 Service Days											
03-Jun-98			●								
09-Sep-98	●	●			●						
23-Sep-98				●							
22-Oct-98									●		
COMNAVBASE: 94-62898 (V8190492) - 57 Service Days											
08-Oct-97	●										
16-Sep-98	●		●							●	
21-Dec-98	●										
PWC Transportation: 94-61120 (V8182690) - 68 Service Days											
06-Feb-98	●		●								
10-Mar-98	●										
05-May-98	●										
18-Nov-98	●					●					
HS-10: 94-62895 (V8195785) - 119 Service Days											
02-Mar-98	●		●								
01-Apr-98											
14-May-98	●										
20-Aug-98	●										●
21-Aug-98	●	●									
26-Aug-98											●
22-Sep-98						●					

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Based on the mileage and energy usage data collected, a progressive and consistent decrease in the energy efficiency of the vehicles (as measured as mi/kWh) was observed from June 1998 to February 1999. Vehicle efficiency showed a decrease of about 0.17 mi/kWh from the high of 1.65 mi/kWh for June 1998. Vehicle efficiency measured in February 1999 ranged from 1.11 to 1.87 mi/kWh and averaged 1.48 mi/kWh per vehicle for all 10 vehicles. A summary the average mi/kWh versus time for the electric pickups is presented as Figure 5-1. The three lowest efficiencies calculated corresponded to the three vehicles with the lowest usage (COMNAVBASE, PWC Zone 1, and PWC Transportation). Although a direct correlation between the amount of use and vehicle efficiency was not observed, a general trend between low vehicle usage and low vehicle efficiency was documented. Because vehicle efficiency is related to a number of factors including ambient air temperature, battery pack condition, and amount of vehicle use, it is difficult to determine the exact cause for the decrease in average vehicle efficiency. One possible cause may be related to seasonal changes in ambient temperature. According to manufacturer information, the batteries operate at optimal output when ambient air temperature is approximately 77 degrees Fahrenheit (Tetra Tech 1999b). As ambient air temperatures decrease from summer to winter, a corresponding drop in battery performance and subsequently in vehicle efficiency could occur. Likewise, as the battery pack ages, it may become less efficient, causing a decrease in the observed vehicle energy efficiency over time. A representative for the vehicle manufacturer suggested that the electric pickups operate best when used often and consistently (Tetra Tech 1999b). However, other than the three low-use vehicles, a clear correlation between the amount of vehicle use and vehicle efficiency was not observed.

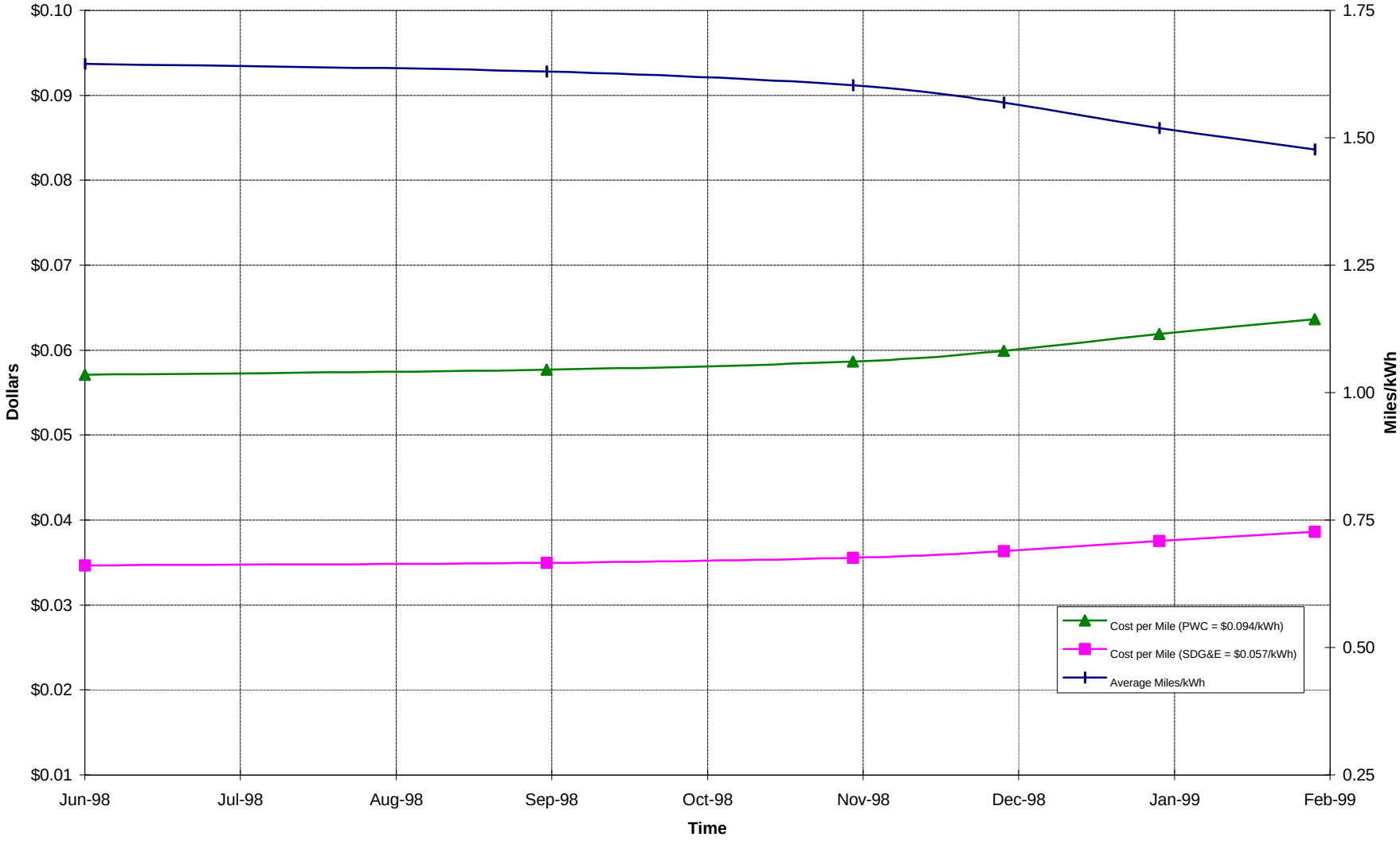
5.2 OPERATING CHARACTERISTICS

Based on the results of the user surveys for the electric-, CNG-, and gasoline-powered pickups, the overall average score for the electric pickups was higher than for both the CNG- and gasoline-powered vehicles. The electric pickup users scored the vehicle higher than the CNG- and gasoline-powered vehicle in the categories of expectations and interior comfort and gauges. Under the category of job applicability, the electric vehicle scored higher than the CNG-powered vehicles but lower than the gasoline-powered vehicles. Overall, these results suggests that vehicle users preferred the electric pickups over CNG- and gasoline-powered vehicles. In fact, when electric vehicle users were asked which type of vehicle would they prefer to drive at work, 16 of the users preferred the electric pickups, six preferred the gasoline-powered vehicles, and none preferred the CNG-powered vehicles.

Overall, the survey results suggest that users expectation for the electric pickup were met, although some users identified concerns with vehicle braking, acceleration, and noise level. Job applicability scores for the electric pickups were 0.1 point less than for those of the gasoline-powered vehicles. The main factors for the electric pickups lower job applicability scores were the vehicle's reliability and, to a lessor extent, its range and payload capacity. The majority of users identified these factors as being less than satisfactory for their work related needs. The electric pickup interior comfort and gauge scores suggest that vehicle users are generally satisfied with this aspect of the vehicle, although some users identified concerns with the air conditioner, heater, and defroster. Charging scores for the electric vehicles were among the highest, suggesting that charging the vehicle did not adversely effect vehicle operation.

Comments provided by the electric pickup users indicated that some of the major problems encountered were: the pickups break down too much, it takes too long to charge the vehicle and the battery does not provide enough energy for a full day of work, and the air conditioner, heater, and defroster work, but take too long and are not very effective. If improvements were made to these

Figure 5-1
Average Miles Per Kilowatt-Hour Versus Time
June 30, 1998 through February 1, 1999



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problems, some of the users who preferred using the gasoline-powered vehicles indicated that they would switch their preference to using the electric pickups.

Based on a review of the cumulative mileage and energy data and electric pickup user surveys, the electric vehicles operated by COMNAVBASE, PWC Zone 1, and PWC Transportation not only had the lowest usage (mileage and energy), but also had the lowest overall average job applicability scores and lowest vehicle reliability scores. The electric pickup operated by PWC Zone 1 was in the shop for repairs for 145 days in 1998, which not only decreased its reliability but also the usage of the vehicle. Although the electric pickups operated by COMNAVBASE and PWC Transportation had low vehicle usage and reliability scores, the number of days the vehicles were in the shop for repair was less than the average vehicle (72 days). Five of the other electric pickups were in the shop about the same or more time then the COMNAVBASE and PWC Transportation electric pickups, suggesting that reliability is not the only factor affecting vehicle usage.

It appears that the electric pickup operated by COMNAVBASE is used primarily by one driver whereas the other electric pickups are used by multiple drivers. This appears to have significantly reduced the COMNAVBASE vehicle use compared to the other electric pickups in this study. The electric pickup operated by PWC Transportation is designated as a loaner for use by tenant activities when another electric pickup is undergoing repair. The limited amount of usage suggests that the vehicle was not loaned out regularly, which is consistent with observations noted during collection of monthly mileage and energy usage data. During the monthly usage collection events for November and December 1998, the electric vehicle operated by AIMD Airframes was in the shop for repair. AIMD Airframes personnel indicated that a loaner vehicle was not provided during this period. However, during this same period, the electric vehicle operated by PWC Transportation was driven less than 28 miles.

5.3 MAINTENANCE CHARACTERISTICS

Based on the results of the study, during the period of September 1, 1997 through February 1, 1999, the electric pickups were in the shop for repair about 14 percent of the time. Based on discussions with PWC Maintenance personnel, CNG- and gasoline-powered vehicles are in the shop for repair less than 2 percent of the time annually.

Maintenance personnel at City Chevrolet indicated that repairs on the electric vehicle require more time than other vehicles because vehicle parts can be obtained only from GM and are typically not stocked by City Chevrolet or local auto parts stores. In addition, nonroutine repairs must be approved in advance by GM electric vehicle personnel. Also, the number of trained mechanics available to repair the electric pickups is limited (two at City Chevrolet), which may affect the speed of repairs, especially when multiple vehicles are in the shop.

The most common maintenance problem encountered was associated with the battery system. GM personnel indicated that maintenance problems with batteries are not limited to the electric pickups at NAS North Island. According to GM, vehicles that are driven frequently without allowing the battery pack to discharge completely experience fewer battery problems. However, this trend was not observed in the data collected for this study.

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The extensive number of repairs and amount of time required to complete the repairs appears to have significantly altered user perception of vehicle reliability as documented in the surveys.

5.4 COST ANALYSIS

Ten Chevrolet S-10 electric pickups were evaluated during this study at NAS North Island. The vehicles operated under similar conditions and were evaluated on qualitative and quantitative data collected during the study. This section presents an economic analysis of the costs for using the electric pickups at NAS North Island. The primary purpose of this economic analysis is to provide a cost estimate of using the Chevrolet S-10 electric pickups for fleet operations at NAS North Island compared to the cost for using CNG- and gasoline-powered vehicles.

This cost analysis is based on the results of and experience gained from the electric vehicle evaluation at NAS North Island, and on energy costs provided by the Navy. Costs for operating the CNG- and gasoline-powered vehicles are based on data provided by the Navy and on vendor-supplied information. Similar costs for the electric vehicles and the CNG- and gasoline-powered vehicles were estimated to calculate a total cost of operating these vehicles. In order to compare the cost of an electric pickup to CNG- and gasoline-powered vehicles, costs are broken down into the following categories:

- Vehicle acquisition costs
- Infrastructure costs
- Operating costs
- Maintenance costs

These categories reflect typical vehicle costs. Each is defined and discussed in this section, forming the basis for the estimated costs presented in Table 5-1. These cost categories are examined and the assumptions made are described in detail below.

Assumptions*:* This economic analysis presents site-specific cost estimates for operating electric pickups for fleet vehicle operations at NAS North Island. This cost estimate is based on the site-specific average vehicle efficiency calculated during the evaluation at NAS North Island. Vehicle efficiencies for the CNG- and gasoline-powered vehicles were provided by the Navy. Energy costs were supplied by the Navy and San Diego Gas & Electric (SDG&E) and represent average yearly energy costs. Actual energy costs will vary greatly by time of use, demand, and season. Important assumptions for each of the four cost categories used for this cost estimate are presented below.

5.4.1 Vehicle Acquisition Cost

Vehicle acquisition costs are limited to the purchase price of a new vehicle. Labor costs for purchase of the vehicles are not included in the acquisition cost. In addition, because the vehicles are owned by the federal government, no sales or license taxes are included in the acquisition costs. For CNG-powered vehicles, acquisition costs include the purchase price of the vehicle and the cost for converting the vehicle to CNG operation. All vehicle purchase and conversion costs were provided by the Navy.

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The electric pickups at NAS North Island were purchased from Chevrolet through the General Services Administration for approximately $34,600 each. The purchase agreement included a 3 year or 36,000 mile bumper-to-bumper warranty. The cost to purchase gasoline-powered pickups is approximately $14,000 per vehicle and includes a warranty similar to the electric pickups. Acquisition cost for the CNG vehicles is the same as for the gasoline-powered vehicle ($14,000), plus an additional $2,500 to convert the vehicle to run on CNG. The conversion cost includes all equipment and labor necessary to modify the vehicle to run on CNG. At NAS North Island, most conversions were completed by PWC; CNG conversions can also be outsourced, or converted vehicles can be purchased directly from the manufacturer. The acquisition costs for the electric-, CNG-, and gasoline-powered pickups are summarized in Table 5-1.

TABLE 5-1

Vehicle Cost Summary
NAS North Island ZEV Evaluation

Costs	Vehicle Type		
	Electric	**CNG**	**Gasoline**
Acquisition	$34,600	$16,500	$14,000
Infrastructure	$6,600 to $8,000	$7,500 to $37,000	NA
Operation	$0.039 to 0.064 per mile	$0.047 to $0.050 per mile	$0.048 to $0.063 per mile
Maintenance	$2,300 per year	$1,025 per year	$1,025 per year

NA Not applicable

5.4.2 Infrastructure Costs

Infrastructure costs include installation and construction costs for vehicle fueling stations and real property improvement such as pavement, fueling islands, natural gas service, electrical service, and concrete pads. Also included are equipment costs such as compressor systems, storage tanks, dispensers, and fuel management systems. Permitting and recurring costs such as health and safety training, operation, and maintenance were not included in infrastructure costs.

Ten Delco Electronic fixed charging stations were installed at NAS North Island for recharging of the electric pickups. Each charging station was installed adjacent to the designated parking area for each electric pickup and was typically within 20 feet of an existing building. Electrical supply from the nearest building was used to power the charging stations, which limited trenching and electric hook-up requirements and costs. A separate electrical meter was also installed to monitor electrical usage at each charging station. The outdoor, floor-mounted charging stations each cost approximately $3,500, and the indoor, wall-mounted charging stations each cost approximately $2,100. Trenching, labor, and supply costs (including electric meters) were about $4,500 for each station (floor- and wall-mounted). The purchase price for the charging stations also included a 3-year warranty on installation and operation.

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CNG-powered vehicles at NAS North Island are fueled at the fixed CNG fueling station, located near the Naval Exchange (NEX) gas station. The CNG fueling station is operated by SDG&E and has three quick-fill dispensers. The station is self-serve and fuel is paid for at the pump using a government-issued fuel card. However, for this cost evaluation, a single-vehicle, fixed, slow-fill CNG fueling station was used to estimate infrastructure costs. These fueling stations were selected for this comparison because they operate in a manner similar to the electric charging stations and because infrastructure costs for installation and construction of the existing CNG fueling station were not available. Single-vehicle fixed CNG fueling stations use the existing natural gas supply system and a small compressor to slow-fill CNG vehicles overnight at the location where the vehicle is parked.

Costs for the slow-fill CNG fueling stations were provided by Fuel Maker, a local CNG fueling vendor. Equipment costs for a small (2 cubic feet per minute [cfm]), single-vehicle slow-fill CNG fueling station are about $5,500. Trenching, natural gas and electrical service, and paving can be provided for about $2,000, assuming that an existing natural gas supply is present in close proximity to the fueling station. Costs for larger fueling stations (10 cfm, for fueling as many as six vehicles at once) are as much as $30,000 for equipment and $7,000 for trenching, natural gas and electrical service, and paving. Additional costs will be incurred for periodic maintenance of the fueling stations, which includes a system inspection at least once every month. Annual maintenance cost for fueling stations depends on the number and type of system purchased and on average is about $1,200 per station. However, maintenance costs for the CNG fueling stations are not included in this cost estimate.

Infrastructure costs for constructing fueling stations for gasoline-powered vehicles were not evaluated as part of this study. In addition to high capital costs for property acquisition, equipment, and construction, gasoline fueling stations also have extensive operating requirements and pose significant environmental liability and health hazards as compared to electric chargers and CNG fueling stations.

5.4.3 Operating Costs

Electricity at NAS North Island is supplied by SDG&E at an average cost of $0.057 per kWh (Tetra Tech 1999c). The electricity supplied by SDG&E is managed and distributed by PWC. The costs for PWC to distribute and manage electricity at NAS North Island are passed on to the energy users, which are charged on average $0.094 per kWh (Tetra Tech 1999c). The rate charged by SDG&E and hence PWC varies greatly based on time of use, demand, and season (rates are higher in the summer and lower in the winter). Given these energy costs and the average electric pickup truck efficiency calculated for this study of 1.48 mi/kWh, the cost per mile to operate the electric pickups is approximately $0.039 to $0.064 per mile.

Fleet operated, CNG-powered vehicles at NAS North Island are fueled at the CNG fast-fueling station adjacent to the NEX gas station. Natural gas for the CNG fueling station is supplied by SDG&E at an average price of about $0.068 per therm (Tetra Tech 1999d). Natural gas at NAS North Island is distributed and managed by PWC. Including costs for PWC to distribute and manage natural gas, the priced charged to NAS North Island customers for CNG is $0.072 per therm (Tetra Tech 1999c). Vehicle energy efficiency as measured by miles per gallon for CNG-powered pickup trucks at NAS North Island is about the same as for gasoline-powered vehicles (17 miles per gallon) (Tetra Tech 1999a). Energy efficiency between CNG- and gasoline-powered vehicles varies depending on the type of CNG vehicle. A factory supplied and dedicated CNG vehicle will be slightly more efficient than

converted or bifuel CNG vehicles. Based on discussions with CNG representatives from SDG&E and PWC, the difference between the efficiency of the CNG- and gasoline-powered vehicles is less than 5 percent and for the purpose of this study is insignificant. Because a therm is a unit of energy and not volume, it is necessary to convert therms to gallons equivalency. One therm is equal to 100,000 British Thermal Units (Btu), assuming 1 cubic foot of natural gas yields 1,000 Btus and 1 therm is equal to 100 cubic feet. One gallon of gasoline is assumed to be equal to 118,000 Btus. Therefore, a factor of 1.18 is used to convert therms to gallons equivalency. Using the 1.18 factor, the per gallon cost equivalency for natural gas supplied by SDG&E is about $0.80 per gallon; cost equivalency for the natural gas distributed by PWC is about $0.85 per gallon. Given the energy cost and vehicle efficiency provided by SDG&E and the Navy, the per mile cost is approximately $0.047 to $0.050 to operate CNG-powered pickups at NAS North Island.

Gasoline-powered fleet vehicles are fueled at the PWC Transportation fueling facility at NAS North Island. At NAS North Island, the Navy purchases fuel using a 2-year, fixed price contract. A new fueling contract was signed in October 1998 to supply unleaded gasoline at $0.81 per gallon (Tetra Tech 1999e). The fuel cost includes California fuel tax, but not federal taxes. Including all state and federal taxes, the average cost for unleaded gasoline is about $1.07 per gallon (as solid at the NEX gas station during 1998) (Tetra Tech 1999e). PWC Transportation personnel estimate that gasoline-powered pickup trucks average about 17 miles per gallon (Tetra Tech 1999a). Given the energy cost and vehicle efficiency provided by the Navy, the cost is approximately $0.048 to $0.063 per mile to operate the gasoline-powered pickups at NAS North Island.

5.4.4 Maintenance Costs

Because the electric pickups are still under warranty, no vehicle maintenance costs have been incurred by the Navy other than vehicle downtime. Maintenance costs for vehicle repairs completed under warranty are provided in Appendix C, Table C-1. From September 1, 1997, to February 1, 1999, the electric pickups have been at City Chevrolet a total of 43 times. Based on cost data provided by City Chevrolet, maintenance costs have exceeded a total of $37,000 for all 43 service events, an average of about $870 per vehicle per visit. Using the maintenance costs to date, annual maintenance costs are estimated to be about $2,800 per vehicle. This estimate may be biased high because several of the maintenance events and costs incurred were part of a manufacturer's recall. Subtracting the axle replacement costs of approximately $760 per vehicle, annual maintenance costs are estimated to be about $2,300. In addition to normal vehicle maintenance and repairs, battery pack replacement may be necessary several times during the lifetime of the electric pickup. Battery replacement depends on a number of factors, including operating conditions, and is difficult to predict. Costs for battery pack replacement may be as high as $15,000 per vehicle. New generation battery packs currently available are reported to store more energy, require less maintenance, and last longer. Battery replacement costs were not included in the electric vehicle maintenance costs.

Based on discussions with PWC maintenance personnel, yearly maintenance requirements for the CNG- and gasoline-powered vehicles are similar and are estimated to be approximately $1,025 per vehicle (Tetra Tech 1999f). These costs include regular preventive maintenance and unscheduled repairs. According to PWC personnel, preventive maintenance for both CNG- and gasoline-powered vehicles is conducted every 7,500 miles and includes changing the oil and filters, checking the brakes and fluid levels, and inspecting the electrical system (Tetra Tech 1999a). Unscheduled repairs typically include tuneups, brakes, transmission, engine, and other repairs. The vehicles are repaired

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by PWC Transportation at NAS North Island. Preventive maintenance can be completed and the vehicle returned to the user within a few hours. The time required to complete unscheduled repairs depends on the type and extent of the repair. Typically, CNG- and gasoline-powered vehicles are repaired within 5 days, and on average, required about 3 days in the shop for maintenance every year (Tetra Tech 1999a and 1999f).

6.0 CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions and recommendations of the electric pickup study conducted at NAS North Island. The conclusions of the study are presented in four areas: energy efficiency, operating characteristics, maintenance characteristics, and cost analysis.

6.1 ENERGY EFFICIENCY

Based on the monthly mileage and energy usage data collected from the 10 electric vehicles, the electric pickups logged more than 30,000 miles and used an estimated 20,000 kWh of electricity from the period September 1, 1997 through February 1, 1999. During this period, each electric pickup was driven an average of 3,020 miles and used an estimated 2,045 kWh. The average energy efficiency for the electric vehicle was about 1.48 mi/kWh. The average energy efficiency has shown a progressive decrease during the last 5 months of monitoring from the high of 1.65 mi/kWh. The cause of decrease in energy efficiency is unknown; however, it is likely related to seasonal changes in ambient air temperature, changes in battery pack condition, and amount of vehicle use. There is a general correlation between the mileage and energy used and the calculated energy efficiencies for the vehicles; the more the vehicle is driven, the higher the energy efficiency appears to be. Continued monitoring of mileage and energy use may provide additional information on potential seasonal variations and vehicle usage on energy efficiency.

6.2 OPERATING CHARACTERISTICS

Based on the user surveys, the electric pickups scored higher than both the CNG- and gasoline-powered vehicles in all categories except job applicability. In general, the electric pickups scored well in performance and low in reliability and other job applicability-related questions. The electric pickup met most user expectations and scored high on charging-related questions.

6.3 MAINTENANCE CHARACTERISTICS

The electric pickups required extensive maintenance during the reporting period. The vehicles were taken to City Chevrolet 43 times for problems related primarily to batteries, coolant leaks, axle replacement, and power steering. City Chevrolet required a total of 722 days to complete the required repairs, or about 14 percent of the time the vehicles were available for use. The most common maintenance problems involved the batteries. According to City Chevrolet, the majority of the battery problems could be averted by proper charging. The electric pickups also had some common problems with power steering and the coolant reservoirs. These problems, as well as the axle replacements, were manufacturer defects. Training on how to properly charge and use the electric vehicles may eliminate some of the battery maintenance problems.

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6.4 COSTS

Costs for the electric pickups included $34,600 to acquire the vehicle, $6,600 to $8,000 for construction of the infrastructure required to operate the vehicles, 0.039 to 0.064 per mile in energy costs to operate the vehicle, and estimated maintenance costs of $2,300 per year. Compared to the costs for CNG- and gasoline-powered vehicles, the electric pickups were more expensive to acquire and maintain and about the same cost for installation of infrastructure and operation of the vehicle. Vehicle acquisition costs for the electric pickups were more than twice the cost of CNG- and gasoline-powered vehicles. Infrastructure costs for the electric charging stations ranged from approximately $6,600 to $8,000, which was comparable to the cost for installing a single vehicle CNG fueling station. (Note: infrastructure costs for gasoline-powered vehicles were not calculated as part of this study). Maintenance costs for the electric vehicle were almost three times that of the CNG- and gasoline-powered vehicles. Operating costs for the electric pickups ranged from about $0.04 to $0.06 per mile, depending on the cost of electricity. These costs were similar to those of the CNG- and gasoline-powered vehicles, which ranged from $0.05 to $0.06 per mile depending on the cost of natural gas and gasoline.

7.0 REFERENCES

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Tetra Tech. 1999c. Record of Telephone Conversation Regarding 1998 Average Electricity and Natural Gas Prices at NAS North Island. Between Ken Decker, Energy Manager, Navy Public Works Department and Ben Hough, Tetra Tech Project Manager. February 3.

Tetra Tech. 1999d. Record of Telephone Conversation Regarding Average Natural Gas Prices at NAS North Island. Between Joe Simarad, San Diego Gas & Electric, Natural Gas Manager and Ben Hough, Tetra Tech Project Manager. February 9.

Tetra Tech. 1999e. Record of Telephone Conversation Regarding Average Gasoline Prices at NAS North Island. Between Naval Exchange Gas Station Staff, Jerry Goldhagen, Tragen Fuel Station Manager, and Ben Hough, Tetra Tech Project Manager. February 8.

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Tetra Tech. 1999f. Record of Telephone Conversation Regarding Maintenance Requirements for Navy Operated Compressed Natural Gas- and Gasoline-Powered Fleet Vehicles. Between Bob Madrigal, Transportation Supervisor and Ben Hough, Tetra Tech Project Manager. February 8.

APPENDIX A

EXAMPLE ZEV-, CNG-, AND GASOLINE-POWERED VEHICLE SURVEYS

ZEV Users Survey

Principal Driver:_____ Date:_____

Activity/Command:_____ Location:_____

Job Application:_____ Vehicle Id:_____

Expectations	**Circle One**					
1. Vehicle's overall acceleration is adequate.	SA	A	NS	D	SD	NA
2. Vehicle accelerates like a gasoline vehicle.	SA	A	NS	D	SD	NA
3. Vehicle accelerates well when cold (first start-up).	SA	A	NS	D	SD	NA
4. Vehicle accelerates well when hot.	SA	A	NS	D	SD	NA
5. Vehicle's overall braking adequate.	SA	A	NS	D	SD	NA
6. Vehicle's brakes operate like a gasoline work vehicle.	SA	A	NS	D	SD	NA
7. Vehicle brakes well with cold brakes (limited use).	SA	A	NS	D	SD	NA
8. Vehicle brake well with hot brakes (heavy use).	SA	A	NS	D	SD	NA
9. Vehicle's power (up hills/heavy load) adequate.	SA	A	NS	D	SD	NA
10. Vehicle's power is similar to a gasoline vehicle.	SA	A	NS	D	SD	NA
11. Vehicle's steering is responsive.	SA	A	NS	D	SD	NA
12. Vehicle maneuvers like a gasoline vehicle.	SA	A	NS	D	SD	NA
13. Vehicle is stable at highway speeds.	SA	A	NS	D	SD	NA
14. Vehicle is stable in wet/icy weather.	SA	A	NS	D	SD	NA
15. Vehicle rides like a gasoline vehicle.	SA	A	NS	D	SD	NA
16. Vehicle cruises at constant speeds well.	SA	A	NS	D	SD	NA
17. Vehicle's operating noise is acceptable.	SA	A	NS	D	SD	NA
18. Vehicle is more quiet than a gasoline vehicle.	SA	A	NS	D	SD	NA
19. Vehicle is louder than a gasoline vehicle.	SA	A	NS	D	SD	NA
Job Applicability						
20. Vehicle is suited for your job application.	SA	A	NS	D	SD	NA
21. The vehicle's range is adequate for your job.	SA	A	NS	D	SD	NA
22. The vehicle's payload capacity is adequate for your job.	SA	A	NS	D	SD	NA
23. The vehicle's power is adequate for your job.	SA	A	NS	D	SD	NA
24. The vehicle's maneuverability is adequate.	SA	A	NS	D	SD	NA
25. The vehicle has been reliable.	SA	A	NS	D	SD	NA
Interior Comfort and Gauges						
26. The battery state of charge gauge is accurate.	SA	A	NS	D	SD	NA
27. The battery energy conservation is gauge accurate.	SA	A	NS	D	SD	NA
28. The vehicle is more quiet inside than a gasoline vehicle.	SA	A	NS	D	SD	NA

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

Interior Comfort and Gauges (Cont.)	**Circle One**					
29. The vehicle is louder inside than a gasoline vehicle.	SA	A	NS	D	SD	NA
30. The heater provides adequate heat.	SA	A	NS	D	SD	NA
31. The defroster works adequately (within 10 min.).	SA	A	NS	D	SD	NA
32. The A/C provides adequate cooling.	SA	A	NS	D	SD	NA
Charging						
33. The vehicle charges fully overnight.	SA	A	NS	D	SD	NA
34. The charging connections are easily made.	SA	A	NS	D	SD	NA
35. Which type of vehicle would you prefer to drive at work?		Electric	Gasoline	CNG		
36. What would you like to see changed about the electric vehicle: (Please enter response below)						
Vehicle Control						
37. Describe vehicle's acceleration quality:	Surges	Smooth	Sluggish	Hesitates		
38. Describe the vehicle's steering quality:	Difficult	Smooth	Wanders	Unstable		
39. Describe the vehicle's ride quality.	Jarring	Rough	Smooth	Unstable		
40. Describe the vehicle's braking quality - cold brakes:	Hard	Jerky	Smooth	Spongy	Weak	
41. Describe the vehicle's braking quality - hot brakes:	Hard	Jerky	Smooth	Spongy	Weak	

COMMENTS:

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

CNG Vehicle Users Survey

Principal Driver:_____ Date:_____

Activity/Command:_____ Location:_____

Job Application:_____ Vehicle Id:_____

Expectations	**Circle One**					
1. Vehicle's overall acceleration is adequate.	SA	A	NS	D	SD	NA
2. Vehicle accelerates like a gasoline vehicle.	SA	A	NS	D	SD	NA
3. Vehicle accelerates well when cold (first start-up).	SA	A	NS	D	SD	NA
4. Vehicle accelerates well when hot.	SA	A	NS	D	SD	NA
5. Vehicle's overall braking adequate.	SA	A	NS	D	SD	NA
6. Vehicle's brakes operate like a gasoline work vehicle.	SA	A	NS	D	SD	NA
7. Vehicle brakes well with cold brakes (limited use).	SA	A	NS	D	SD	NA
8. Vehicle brake well with hot brakes (heavy use).	SA	A	NS	D	SD	NA
9. Vehicle's power (up hills/heavy load) adequate.	SA	A	NS	D	SD	NA
10. Vehicle's power is similar to a gasoline vehicle.	SA	A	NS	D	SD	NA
11. Vehicle's steering is responsive.	SA	A	NS	D	SD	NA
12. Vehicle maneuvers like a gasoline vehicle.	SA	A	NS	D	SD	NA
13. Vehicle is stable at highway speeds.	SA	A	NS	D	SD	NA
14. Vehicle is stable in wet/icy weather.	SA	A	NS	D	SD	NA
15. Vehicle rides like a gasoline vehicle.	SA	A	NS	D	SD	NA
16. Vehicle cruises at constant speeds well.	SA	A	NS	D	SD	NA
17. Vehicle's operating noise is acceptable.	SA	A	NS	D	SD	NA
18. Vehicle is more quiet than a gasoline vehicle.	SA	A	NS	D	SD	NA
19. Vehicle is louder than a gasoline vehicle.	SA	A	NS	D	SD	NA
Job Applicability						
20. Vehicle is suited for your job application.	SA	A	NS	D	SD	NA
21. The vehicle's range is adequate for your job.	SA	A	NS	D	SD	NA
22. The vehicle's payload capacity is adequate for your job.	SA	A	NS	D	SD	NA
23. The vehicle's power is adequate for your job.	SA	A	NS	D	SD	NA
24. The vehicle's maneuverability is adequate.	SA	A	NS	D	SD	NA
25. The vehicle has been reliable.	SA	A	NS	D	SD	NA
Interior Comfort and Gauges						
26. The CNG gauge is accurate.	SA	A	NS	D	SD	NA
27. The vehicle is more quiet inside than a gasoline vehicle.	SA	A	NS	D	SD	NA

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

Interior Comfort and Gauges (Cont.)	**Circle One**					
29. The vehicle is louder inside than a gasoline vehicle.	SA	A	NS	D	SD	NA
30. The heater provides adequate heat.	SA	A	NS	D	SD	NA
31. The defroster works adequately (within 10 min.).	SA	A	NS	D	SD	NA
32. The A/C provides adequate cooling.	SA	A	NS	D	SD	NA

33. Which type of vehicle would you prefer to drive at work? Electric Gasoline CNG

34. What would you like to see changed about the electric vehicle: (Please enter response below)

Vehicle Control

35. Describe vehicle's acceleration quality:	Surges	Smooth	Sluggish	Hesitates	
36. Describe the vehicle's steering quality:	Difficult	Smooth	Wanders	Unstable	
37. Describe the vehicle's ride quality.	Jarring	Rough	Smooth	Unstable	
38. Describe the vehicle's braking quality - cold brakes:	Hard	Jerky	Smooth	Spongy	Weak
39. Describe the vehicle's braking quality - hot brakes:	Hard	Jerky	Smooth	Spongy	Weak

COMMENTS:

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

Gasoline Vehicle Users Survey

Principal Driver:_____ Date:_____

Activity/Command:_____ Location:_____

Job Application:_____ Vehicle Id:_____

Expectations	**Circle One**					
1. Vehicle's overall acceleration is adequate.	SA	A	NS	D	SD	NA
2. Vehicle accelerates well when cold (first start-up).	SA	A	NS	D	SD	NA
3. Vehicle accelerates well when hot.	SA	A	NS	D	SD	NA
4. Vehicle's overall braking adequate.	SA	A	NS	D	SD	NA
5. Vehicle brakes well with cold brakes (limited use).	SA	A	NS	D	SD	NA
6. Vehicle brake well with hot brakes (heavy use).	SA	A	NS	D	SD	NA
7. Vehicle's power (up hills/heavy load) adequate.	SA	A	NS	D	SD	NA
8. Vehicle's power is good.	SA	A	NS	D	SD	NA
9. Vehicle's steering is responsive.	SA	A	NS	D	SD	NA
10. Vehicle maneuvers well.	SA	A	NS	D	SD	NA
11. Vehicle is stable at highway speeds.	SA	A	NS	D	SD	NA
12. Vehicle is stable in wet/icy weather.	SA	A	NS	D	SD	NA
13. Vehicle rides smoothly.	SA	A	NS	D	SD	NA
14. Vehicle cruises at constant speeds well.	SA	A	NS	D	SD	NA
15. Vehicle's operating noise is acceptable.	SA	A	NS	D	SD	NA
Job Applicability						
18. Vehicle is suited for your job application.	SA	A	NS	D	SD	NA
19. The vehicle's range is adequate for your job.	SA	A	NS	D	SD	NA
20. The vehicle's payload capacity is adequate for your job.	SA	A	NS	D	SD	NA
21. The vehicle's power is adequate for your job.	SA	A	NS	D	SD	NA
22. The vehicle's maneuverability is adequate.	SA	A	NS	D	SD	NA
23. The vehicle has been reliable.	SA	A	NS	D	SD	NA
Interior Comfort and Gauges						
26. The fuel gauge is accurate.	SA	A	NS	D	SD	NA
27. The vehicle is quiet inside.	SA	A	NS	D	SD	NA

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

Interior Comfort and Gauges (Cont.) **Circle One**

29. The vehicle is loud inside.	SA	A	NS	D	SD	NA
30. The heater provides adequate heat.	SA	A	NS	D	SD	NA
31. The defroster works adequately (within 10 min.).	SA	A	NS	D	SD	NA
32. The A/C provides adequate cooling.	SA	A	NS	D	SD	NA

33. Which type of vehicle would you prefer to drive at work? Electric Gasoline CNG

34. What would you like to see changed about the electric vehicle: (Please enter response below)

Vehicle Control

35. Describe vehicle's acceleration quality:	Surges	Smooth	Sluggish	Hesitates	
36. Describe the vehicle's steering quality:	Difficult	Smooth	Wanders	Unstable	
37. Describe the vehicle's ride quality.	Jarring	Rough	Smooth	Unstable	
38. Describe the vehicle's braking quality - cold brakes:	Hard	Jerky	Smooth	Spongy	Weak
39. Describe the vehicle's braking quality - hot brakes:	Hard	Jerky	Smooth	Spongy	Weak

COMMENTS:

SA - Strongly Agree, A - Agree, NS - Not Sure, D - Disagree, SD - Strongly Disagree, NA - Not Applicable

APPENDIX B

MILEAGE AND ENERGY VERSUS TIME PLOTS

Figure B-1
Summary Averages
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

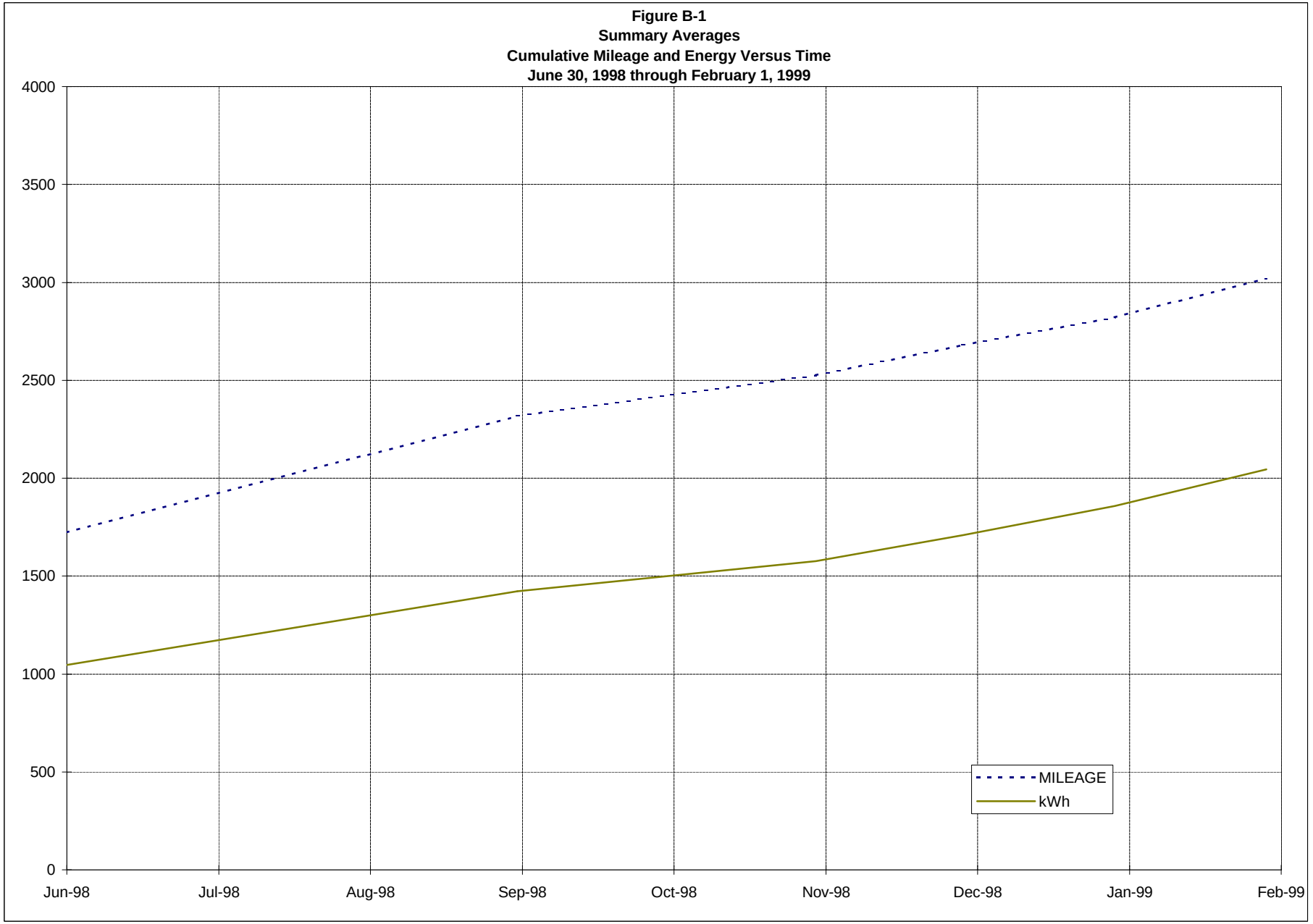


Figure B-2
Staff Civil Engineer EP1
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

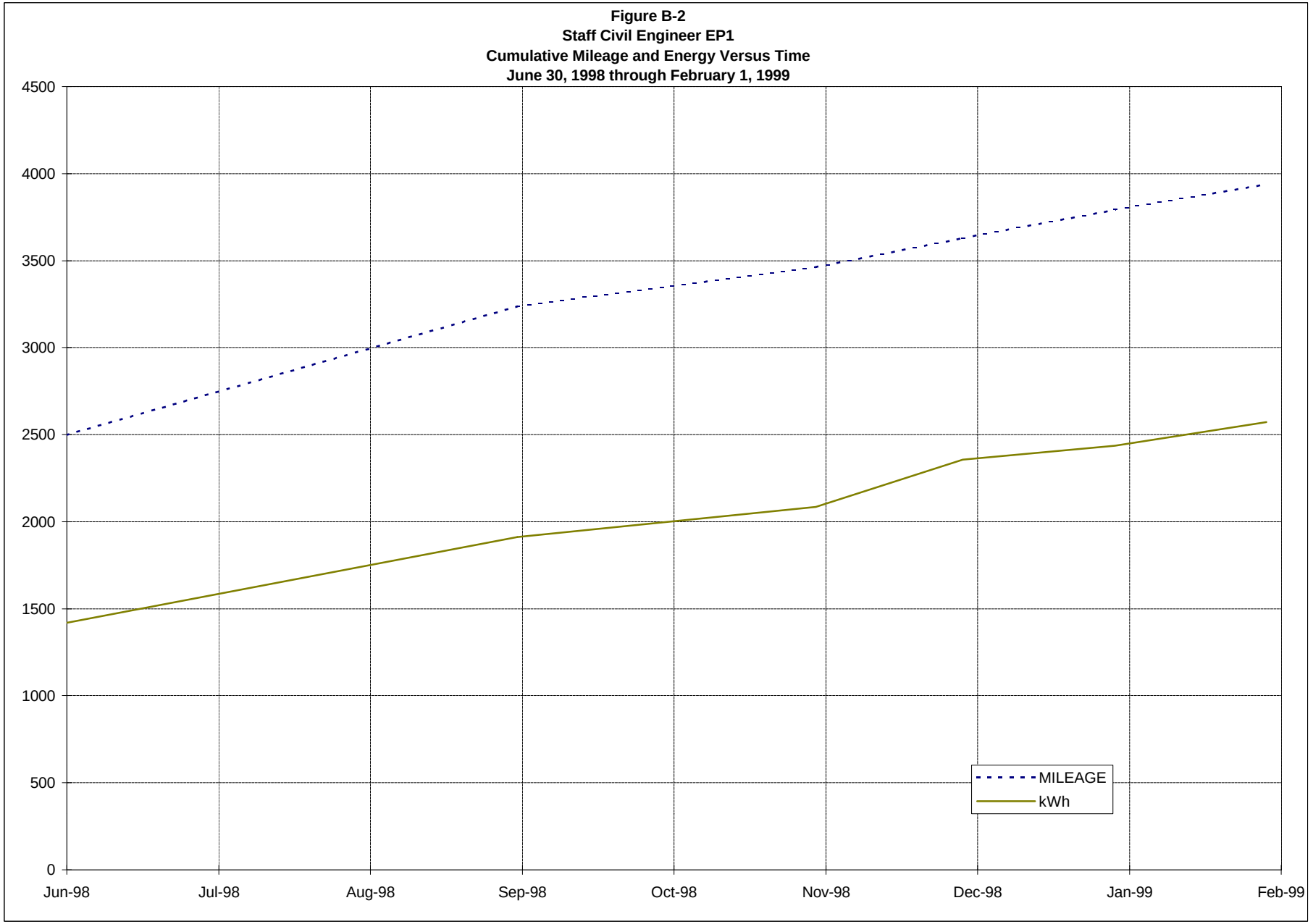


Figure B-3
Staff Civil Engineer EP2
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

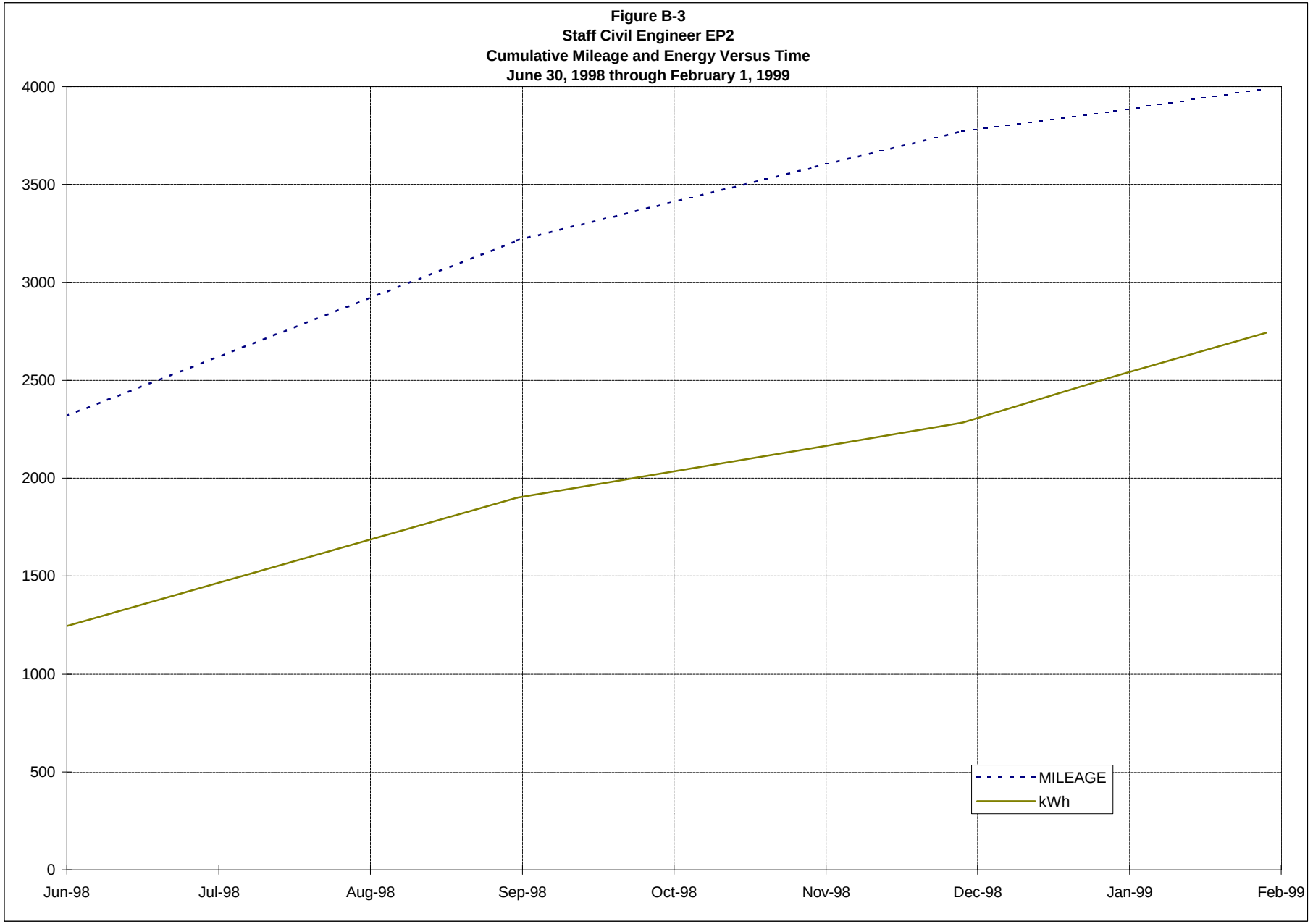


Figure B-4
AIMD Airframes
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

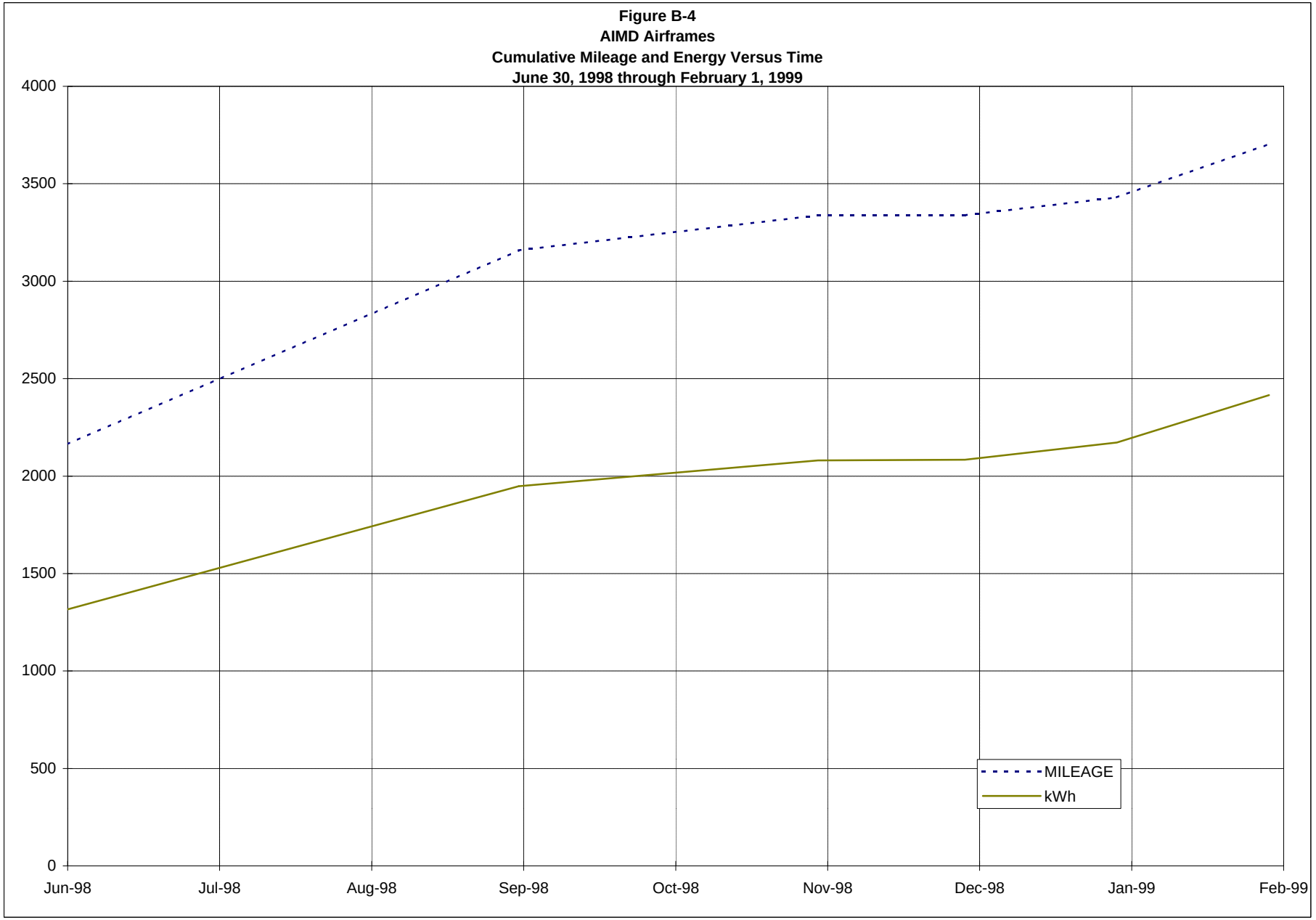


Figure B-5
Operations Dept
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

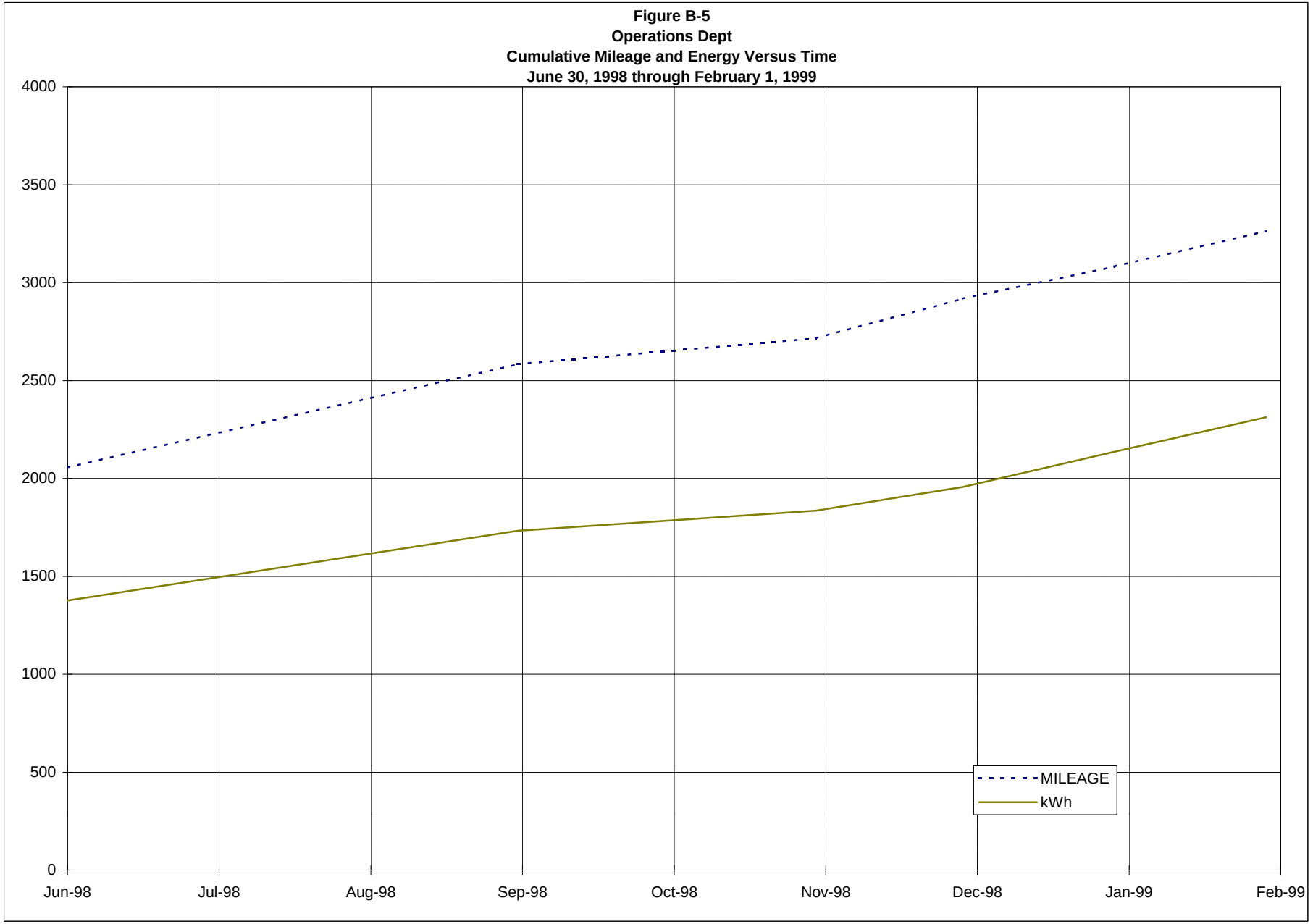


Figure B-6
HS-10 Warhawks
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

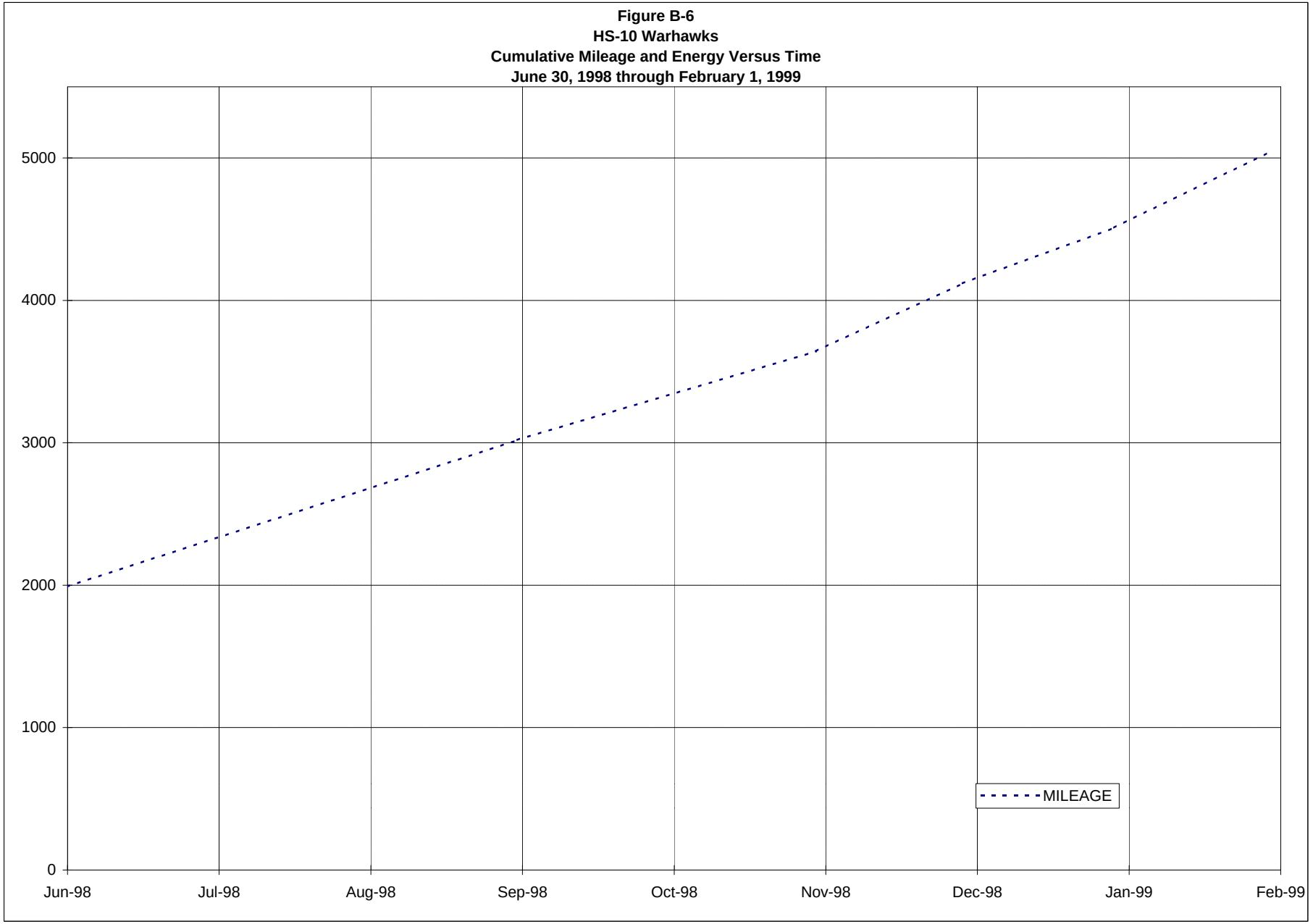


Figure B-7
Supply Dept/Galley
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

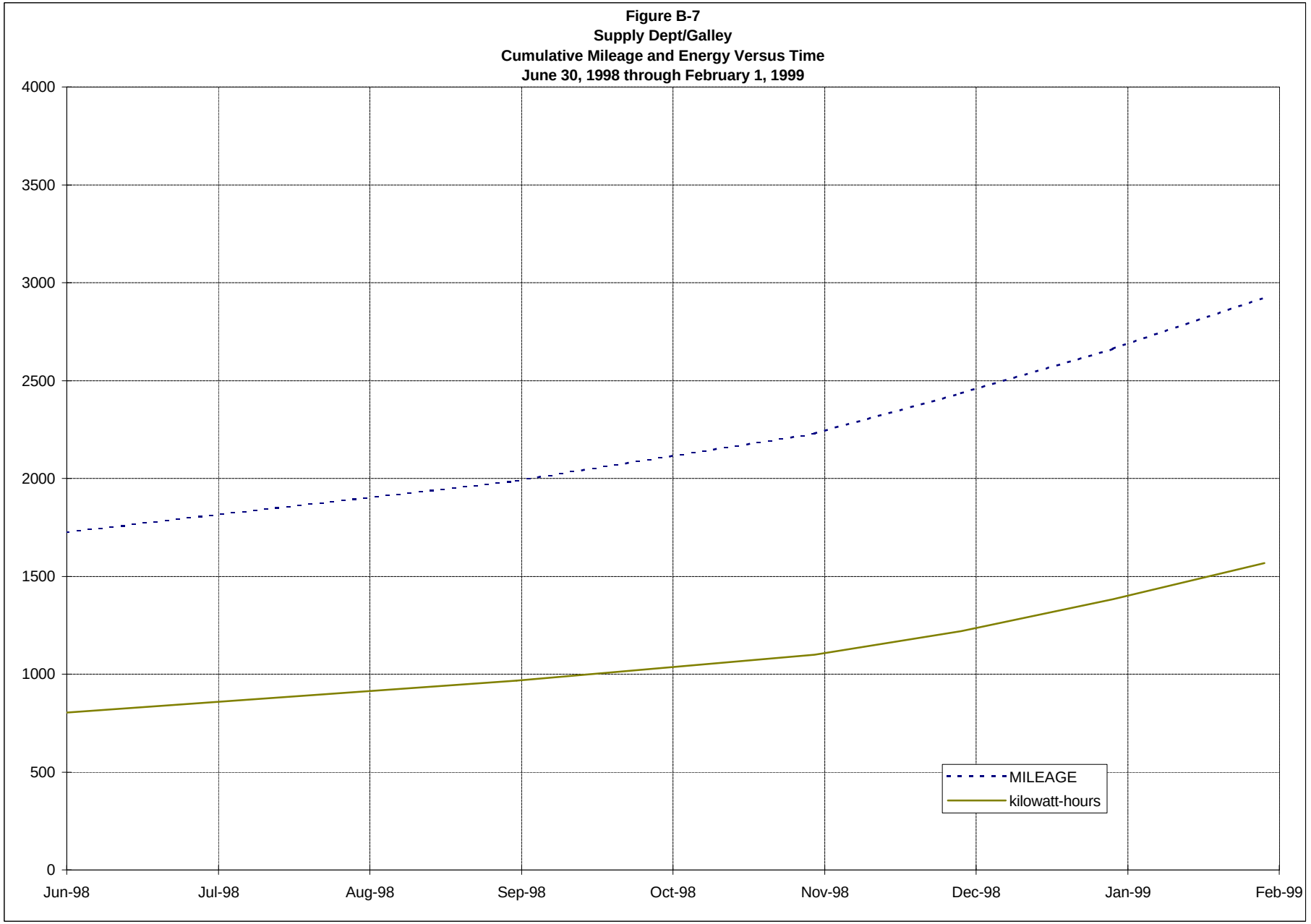


Figure B-8
NADEP Environ Dept
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

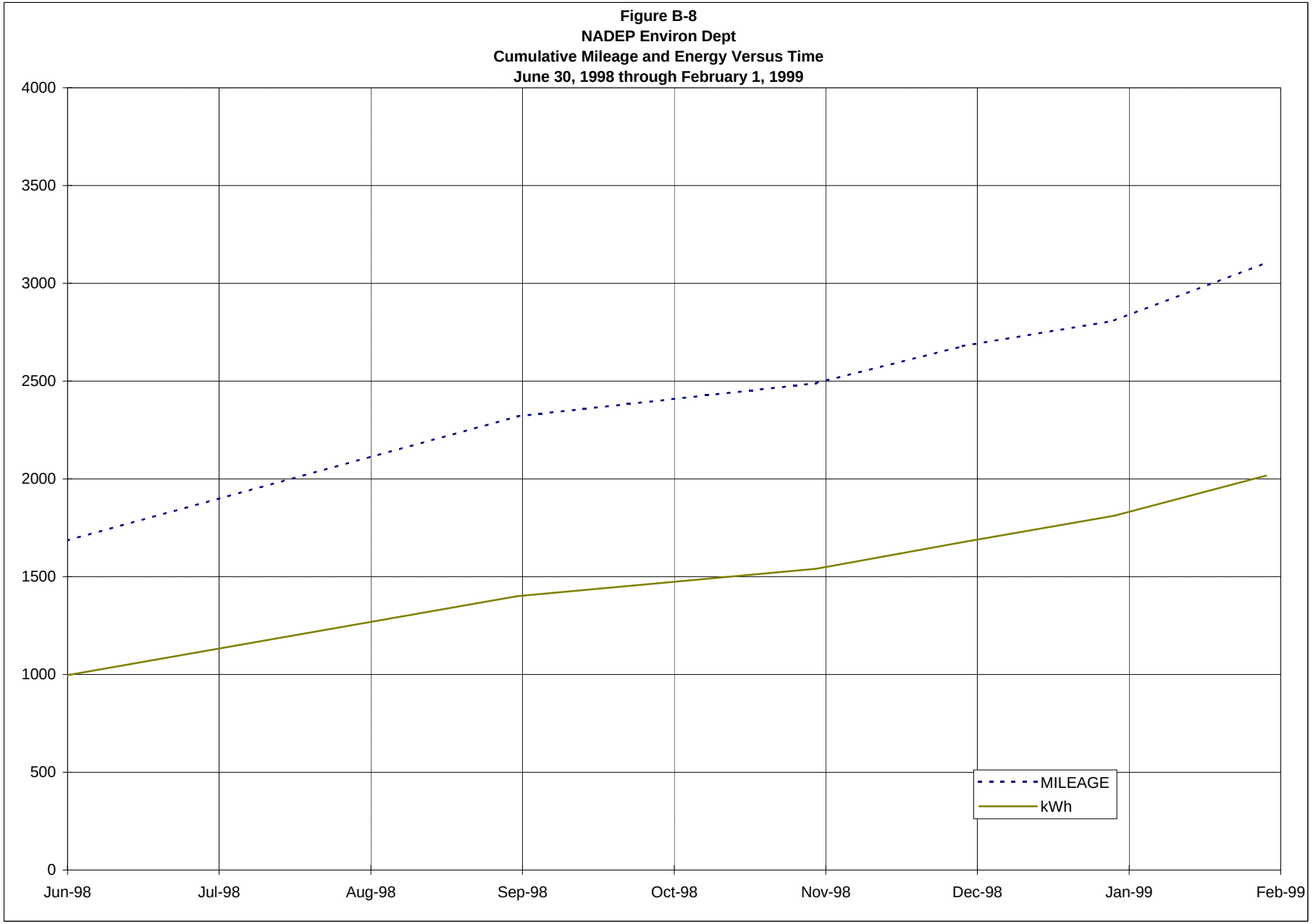


Figure B-9
COMNAVBASE SD
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

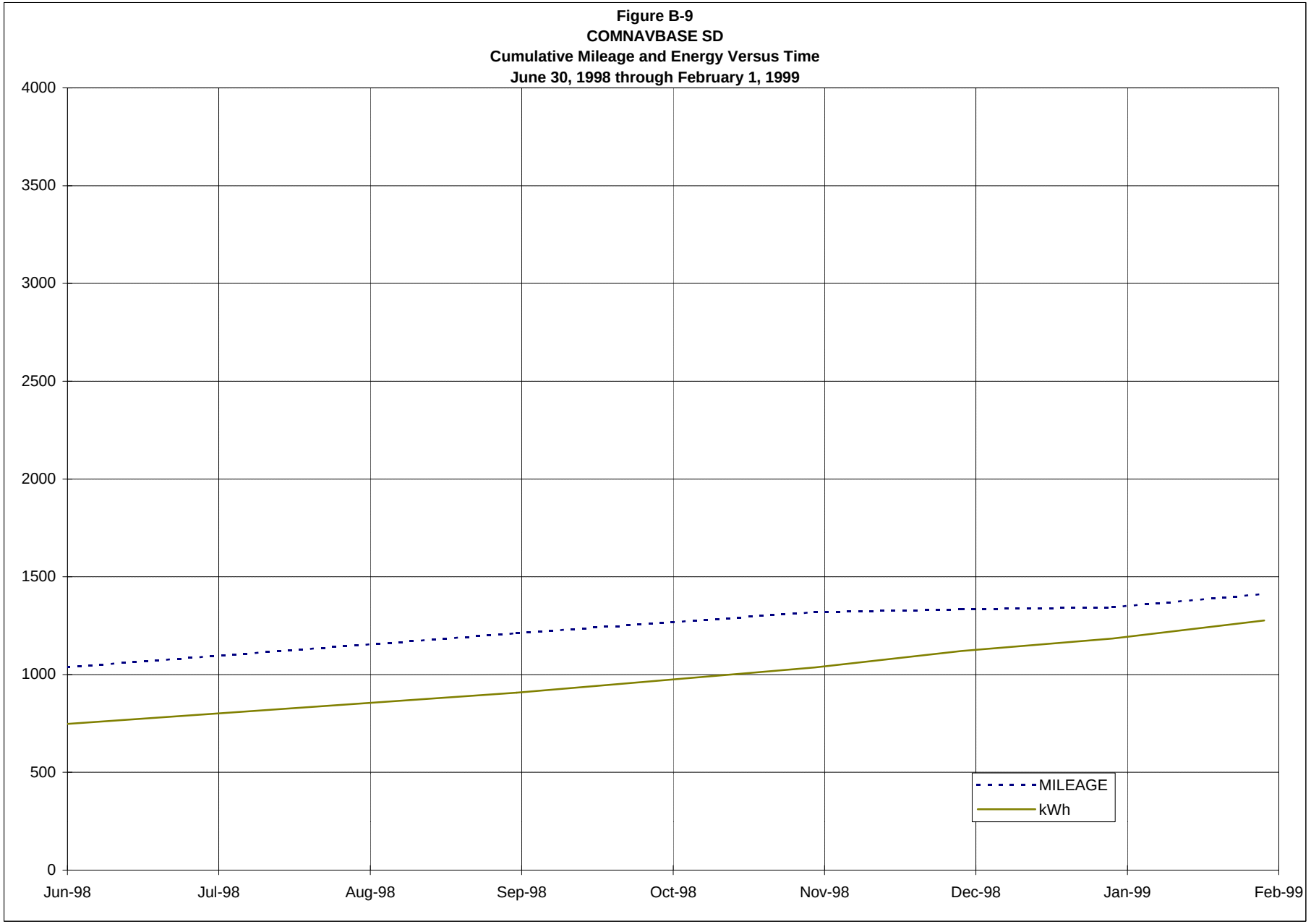


Figure B-10
PWC Zone 1
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999

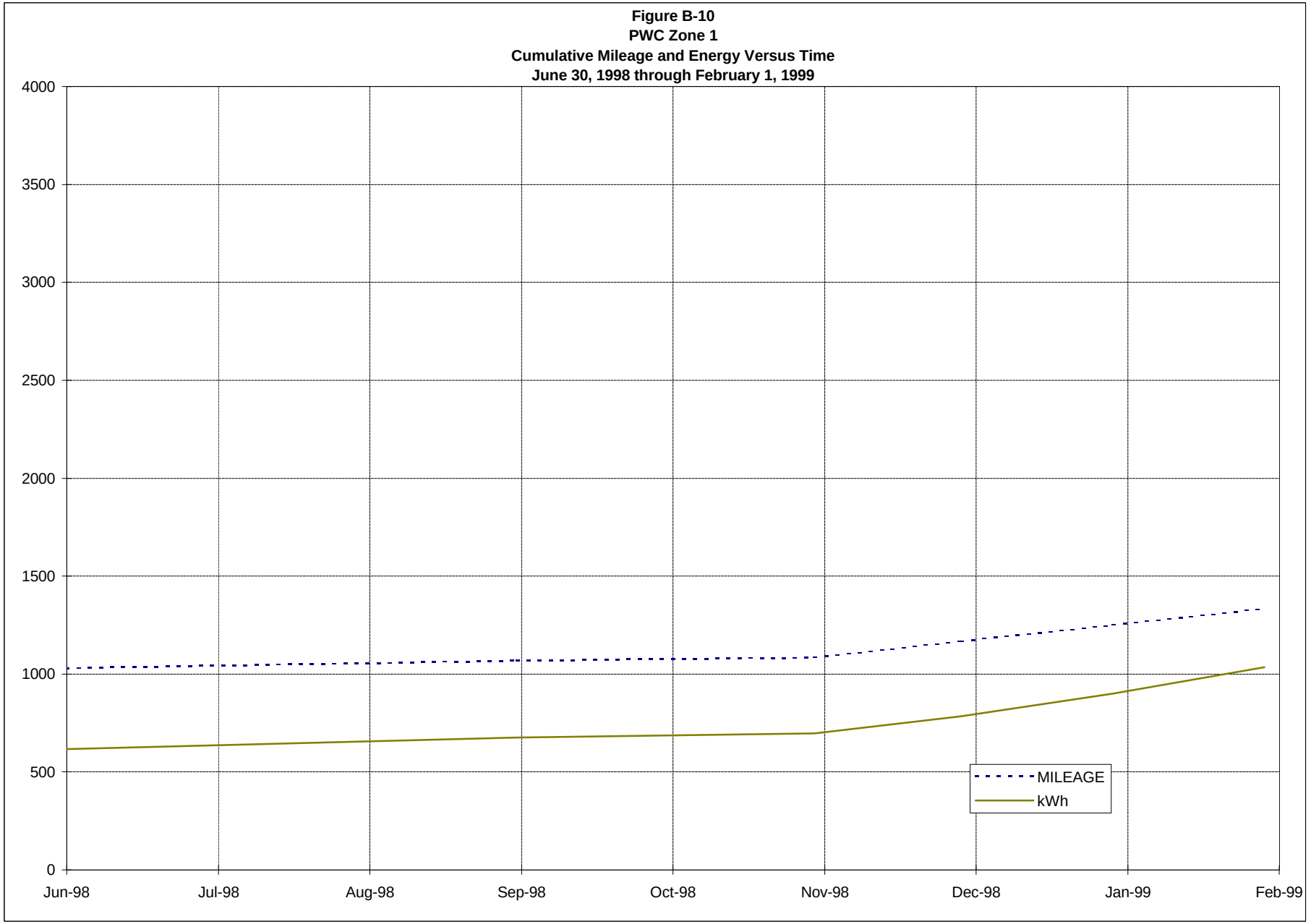
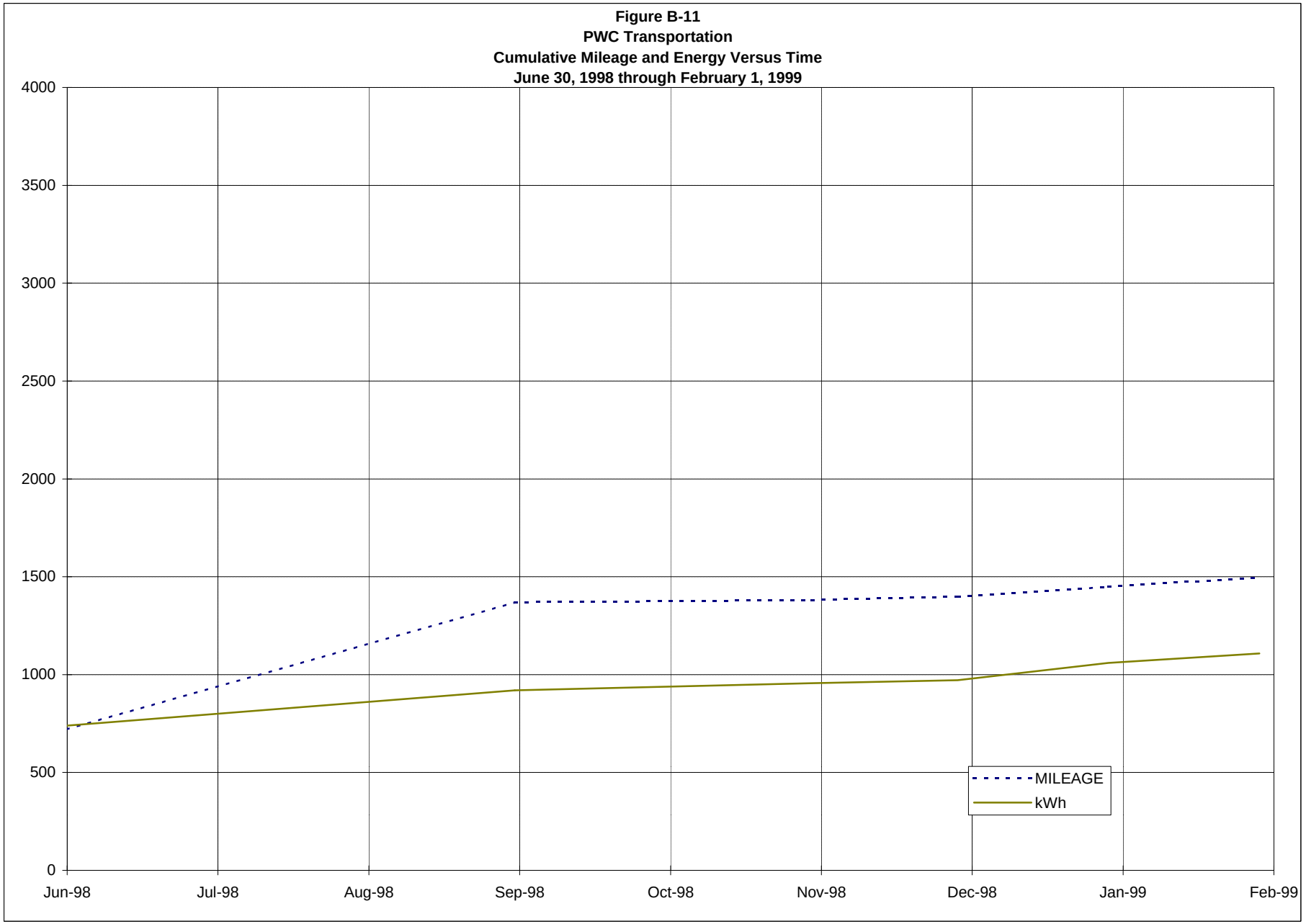


Figure B-11
PWC Transportation
Cumulative Mileage and Energy Versus Time
June 30, 1998 through February 1, 1999



APPENDIX C

INDIVIDUAL ELECTRIC PICKUP RESULTS

C. Individual Vehicle Results

This section presents the monthly mileage and energy usage, user survey results, and maintenance records review for each electric pickup at the following tenant activities: Staff Civil Engineer (2 vehicles, EP-1 and EP-2), Aircraft Intermediate Maintenance Department (AIMD) Airframes, Operations Department, HS-10 Warhawks, Supply Department/Galley, Naval Aviation Depot (NADEP) Environmental Department, and Commander Naval Base San Diego (COMNAVBASE), Public Works Center (PWC) Zone 1, and PWC Transportation.

C.1 Staff Civil Engineer (EP-1 and EP-2)

Mileage and energy usage data for the two electric pickups at Staff Civil Engineering (SCE) are similar. As of February 1, 1999, EP-1 had been driven 3,938 miles and used about 2,472 kilowatt hours (kWh) of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 206 miles per month, and the vehicle's efficiency decreased from 1.76 miles per kWh (mi/kWh) to 1.53 mi/kWh. As of February 1, 1999, EP-2 has been driven over 3,990 miles and used about 2,744 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 239 miles per month and the vehicle's efficiency decreased from 1.86 mi/kWh to 1.45 mi/kWh.

Two electric pickups from SCE users were surveyed. The overall average survey result was 3.8 on a satisfaction scale of 1 to 5, with 5 representing maximum satisfaction. This result is fairly comparable with the overall average survey result of 4.0 for all electric pickup users. A summary of the average survey results for each of the four survey categories is presented in the table below.

One SCE user also completed a CNG-powered vehicle survey. The average survey result for the CNG-powered vehicles was 3.3. The CNG vehicle user scored the CNG-powered vehicle lower than the electric vehicle in the following categories: expectations, internal gauges and comfort, and overall satisfaction. A summary of the average survey results for each of the three survey categories for the CNG-powered vehicle is presented in the table below.

EP-1/EP-2	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	3.8	3.8	4.0	4.0	3.8
CNG	2.9	4.0	3.7	-	3.3

The overall scores for the two SCE electric pickup users were 3.7 and 4.0. Both users considered the electric pickup to be reliable. The electric pickup's range and power were the primary areas of dissatisfaction.

The EP-1 electric pickup at SCE was brought in for service twice in 1997 and three time in 1998. In these cases, service was required to address battery and charging problems. The batteries were exercised and charged each time the vehicle was brought in. The axles were also replaced as a part of a manufacturer's recall, and the coolant was refilled on one occasion. The EP-2 electric vehicle was brought in for service once in 1997 and three times in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, replacing the power steering column and pump, and exercising

and charging the batteries. The EP-1 electric pickup was serviced a total of 84 days; the EP-2 electric pickup was serviced a total of 83 days.

C.2 Aircraft Intermediate Maintenance Department Airframes

As of February 1, 1999, the electric pickup at AIMD Airframes had been driven more than 3,704 miles and used about 2,416 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 220 miles per month, and the vehicle's efficiency decreased from 1.64 mi/kWh to 1.53 mi/kWh.

A total of four electric pickup users from AIMD Airframes were surveyed. The overall average survey result was 3.8. This result is fairly comparable with the overall average survey result of 4.0 for all electric pickup users surveyed. A summary of the average survey results for each of the survey categories is presented in the table below.

The overall scores for each AIMD Airframes electric pickup user were 4.0, 3.8, 3.9, and 3.7. Three out of the four users considered the electric vehicle unreliable. AIMD Airframe users also completed four surveys for both compressed natural gas- (CNG) and gasoline-powered vehicles. The average survey result for CNG-powered vehicles was 3.5 and the average survey result for the gasoline-powered vehicles was 2.8. A summary of the average survey results for each of the three survey categories for the CNG- and gasoline-powered vehicles is presented in the table below. Although AIMD Airframe users considered the CNG- and gasoline-powered vehicles more reliable than the electric pickups, the surveys indicate they are more satisfied overall with the electric pickups.

AIMD	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	4.0	3.8	3.7	3.9	3.8
CNG	3.4	3.8	3.4	-	3.5
Gasoline	2.6	3.5	2.5	-	2.8

The electric pickup at AIMD Airframes was brought in for service three times in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, refilling the coolant reservoir, inspecting the heater, and exercising and fully charging the batteries. The AIMD Airframe electric vehicle has been serviced a total of 59 days.

C.3 Operations Department

As of February 1, 1999, the electric pickup at the Operations Department had been driven more than 3,264 miles and used about 2,312 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 173 miles per month and the vehicle's efficiency decreased from 1.49 mi/kWh to 1.41 mi/kWh.

A total of four electric pickup users were surveyed from the Operations Department. The overall average survey result was 4.5, the highest overall score for all electric pickup users surveyed. A summary of the average survey results for each of the four survey categories is presented in the table below.

Operations Department	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	4.6	4.4	4.2	4.3	4.5

The overall scores for each Operations Department user were 4.6, 4.4, 4.5, and 4.4. The higher survey scores may be related to the amount of time the vehicle has been serviced; the Operations Department has been able to more consistently rely on their vehicle than other users.

The electric pickup at the Operations Department was brought in for service four times in 1998. This electric pickup has been serviced less than any other vehicle, requiring only 10 service days for the repairs. Maintenance included minor battery problems and replacing the axles as a part of a manufacturer's recall.

C.4 HS-10 Warhawks

As of February 1, 1999, the electric pickup at HS-10 Warhawks had been driven more than 5,032 miles and used an estimated 3,407 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 435 miles per month, and the vehicle's efficiency decreased from 1.65 mi/kWh to 1.48 mi/kWh.

A total of three electric pickup users were surveyed from HS-10 Warhawks. The overall average survey result was 4.1, comparable with the overall average survey result of 4.0 for all electric pickup users surveyed. A summary of the average survey results for each of the four survey categories is presented in the table below.

HS-10 Warhawks users also completed four surveys for gasoline-powered vehicles. The average survey result for the gasoline-powered vehicles was 3.8. A summary of the average survey results for each of the three survey categories for the gasoline-powered vehicles is presented in the table below.

HS-10 Warhawk	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	4.1	3.8	4.1	4.7	4.1
Gasoline	3.8	3.6	3.8	-	3.8

The Job Applicability average survey result for the electric vehicles brought the user's overall average survey result down considerably. The users found the electric pickup in general to be unreliable and unsuited for the job. Maintenance appears to have been the primary source of dissatisfaction with the vehicle, although the overall average survey result is still favorable. HS-10 Warhawks was without the vehicle for more than 30 percent of 1998. Even with these problems, electric pickup users scored the electric-powered vehicles higher than the gasoline powered vehicles in all categories.

The electric pickup at HS-10 Warhawk was brought in for service seven times in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, replacing the coolant reservoir, body work, and exercising and fully charging the batteries. These repairs required a total of 119 days.

C.5 Supply Department/Galley

As of February 1, 1999, the electric pickup at the Supply Department has been driven more than 2,925 miles and used about 1,568 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 171 miles per month, and the vehicle's efficiency decreased from 2.15 mi/kWh to 1.87 mi/kWh.

A total of four electric pickup users were surveyed from the Supply Department. The overall average survey result was 3.7, low when compared with the overall average survey result of 4.0 for all electric pickup users surveyed. A summary of the average survey results for each of the four survey categories is presented in the table below.

Supply Department users also completed four surveys for gasoline-powered vehicles. The average survey result for the gasoline-powered vehicles was 3.9. In all cases, gasoline-powered vehicles scored higher than electric-powered vehicles, suggesting that the users preferred the gasoline-powered vehicles. A summary of the average survey results for each of the three survey categories for the gasoline-powered vehicles is presented in the table below.

Supply Department	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	3.7	4.0	3.4	4.5	3.7
Gasoline	3.8	4.6	3.4	-	3.9

The overall scores for each electric pickup user were 3.9, 3.7, 3.7, and 3.6. All four users considered the electric pickup unreliable, which may be partially attributed by extensive maintenance problems encountered. The Supply Department was without the electric vehicle for more than 20 percent of 1998.

The electric pickup at the Supply Department was brought in for service twice in 1997 and four times in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, replacing the power steering module, exercising and fully charging the batteries, and replacing a battery module. The Supply Department electric vehicle has been serviced a total of 87 days.

C.6 Naval Aviation Depot Environmental Department

As of February 1, 1999, the electric pickup at NADEP has been driven more than 3,106 miles and used about 2,016 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven approximately 203 miles per month, and the vehicle's efficiency decreased from 1.69 mi/kWh to 1.54 mi/kWh.

A total of four electric pickup users were surveyed from NADEP. The overall average survey result was 4.0, among the highest average survey results. A summary of the average survey results for each of the four survey categories is presented in the table below.

NADEP	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	4.1	4.0	3.8	4.1	4.0

The overall scores for each electric vehicle user at NADEP were 3.8, 3.9, 3.8, and 4.6. Two out of the four users considered the electric vehicle unreliable. One user was extremely satisfied with the electric vehicle. The driving range was the primary concern of the NADEP users. Maintenance issues with the electric pickup appear to have not adversely affected the survey results.

The electric pickup at NADEP was brought in for service once in 1997 and twice in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, refilling the coolant reservoir, and exercising and fully charging the batteries, replacing parts in the charging system, and charging the auxiliary battery. The NADEP electric pickup has been serviced a total of 10 days.

C.7 Commander Navy Base San Diego

As of February 1, 1999, the electric pickup at COMNAVBASE has been driven more than 1,413 miles and used about 1,276 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven approximately 54 miles per month, and the vehicle's efficiency decreased from 1.39 mi/kWh to 1.11 mi/kWh.

The electric pickup at COMNAVBASE has one primary user, so only one electric pickup user survey was obtained. The overall average survey result was 3.9. A summary of the average survey results for each of the four survey categories is presented in the table below.

COMNAVBASE	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	4.2	3.5	3.7	4.0	3.9

The user found the vehicle reliable and suited to the job. Vehicle range was adequate and the user has had limited problems with the vehicle. The only concern is that the electric pickup travels at a constant speed after the user lets up on the acceleration pedal. It is necessary to brake to slow down the vehicle.

The electric pickup at COMNAVBASE was brought in for service once in 1997 and twice in 1998. In 1997, the customer's concern was not duplicated at the service center. In 1998, maintenance included replacing the axles as a part of a manufacturer's recall and charging the auxiliary battery. These repairs required a total of 57 days to complete.

C.8 Public Works Center Zone 1

As of February 1, 1999, the electric pickup at PWC Zone 1 has been driven more than 1,334 miles and used about 1,036 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven an average of 43 miles per month, and the vehicle's efficiency decreased from 1.67 mi/kWh to 1.29 mi/kWh.

One electric vehicle user was surveyed from PWC Zone 1. The overall average survey result was 3.6, the lowest average survey result for all electric pickup users surveyed. A summary of the average survey results for each of the survey categories is presented in the table below.

The Job Applicability average survey result brought the user's overall average survey result down considerably. The user found the electric vehicle unreliable and unsuited for the job. The user also had problems with the accuracy of the battery gauge. It is likely that the primary cause of the user's dissatisfaction is the total number of service days for the electric pickup last year. The user was without the vehicle about 40 percent of the time (145 days).

One CNG and gasoline-powered vehicle user was also surveyed from PWC Zone 1. The overall average survey results for the CNG-and gasoline-powered vehicles were 3.8 and 4.7, respectively. These results were the highest average survey result of the CNG- and gasoline-powered vehicle users surveyed. This user also indicated that he preferred driving the CNG vehicle over the electric and gasoline vehicles. Most other CNG users indicated that they preferred gasoline-powered vehicles.

PWC Zone 1	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	3.7	3.2	3.6	4.0	3.6
CNG	3.8	4.0	3.8	-	3.8
Gasoline	4.9	5.0	3.8	-	4.7

The electric pickup at PWC Zone 1 was brought in for service once in 1997 and three times in 1998. Maintenance included exercising and fully charging the batteries, replacing the part in the charging system, and charging the auxiliary battery. These repairs required a total of 145 days to complete.

C.9 Public Works Center Transportation

As of February 1, 1999, the electric pickup at PWC Transportation has been driven more than 1,497 miles and used about 1,108 kWh of energy. During the 7 month period from June 30, 1998 to February 1, 1999, the vehicle was driven approximately 111 miles per month, and the vehicle's efficiency increased from 0.97 mi/kWh to 1.35 mi/kWh.

One electric pickup user was surveyed from PWC Transportation. The overall average survey result was 4.2, one of the highest of all electric pickups users surveyed. A summary of the average survey results for each of the four survey categories is presented in the table below.

PWC Transportation	Expectations	Job Applicability	Internal Gauges and Comfort	Charging	Overall
Electric	5.0	2.7	3.3	5.0	4.2

The Job Applicability average survey result brought the user's overall average survey result down considerably. The Job Applicability scored the lowest of all users surveyed and the Expectations scored the highest of all users surveyed. The user found the electric vehicle to be very unreliable and unsuited for the job. Range, payload, reliability, the air conditioning system, and the heater and

defroster were the areas of dissatisfaction. Maintenance appears to have been the primary source of dissatisfaction with the vehicle, although the overall average survey result is highly favorable.

The electric pickup at PWC Transportation was brought in for service four times in 1998. Maintenance included replacing the axles as a part of a manufacturer's recall, exercising and charging the batteries, and replacing a battery module. The electric pickup was brought in for battery and charger problems all four times it was serviced. These repairs required a total of 68 days to complete.

Figure C-1
Survey Results - Expectations

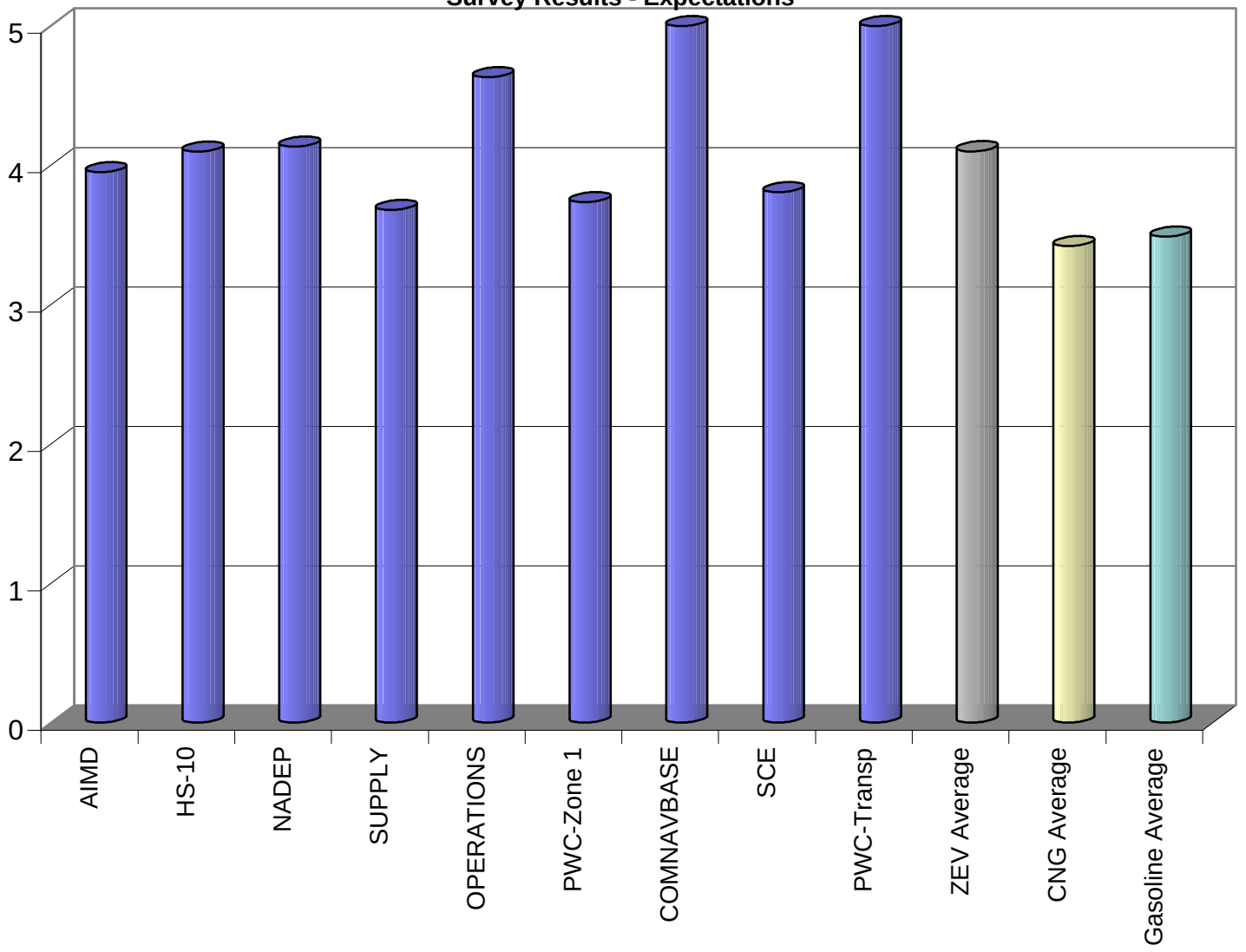


Figure C-2
Survey Results- Job Applicability

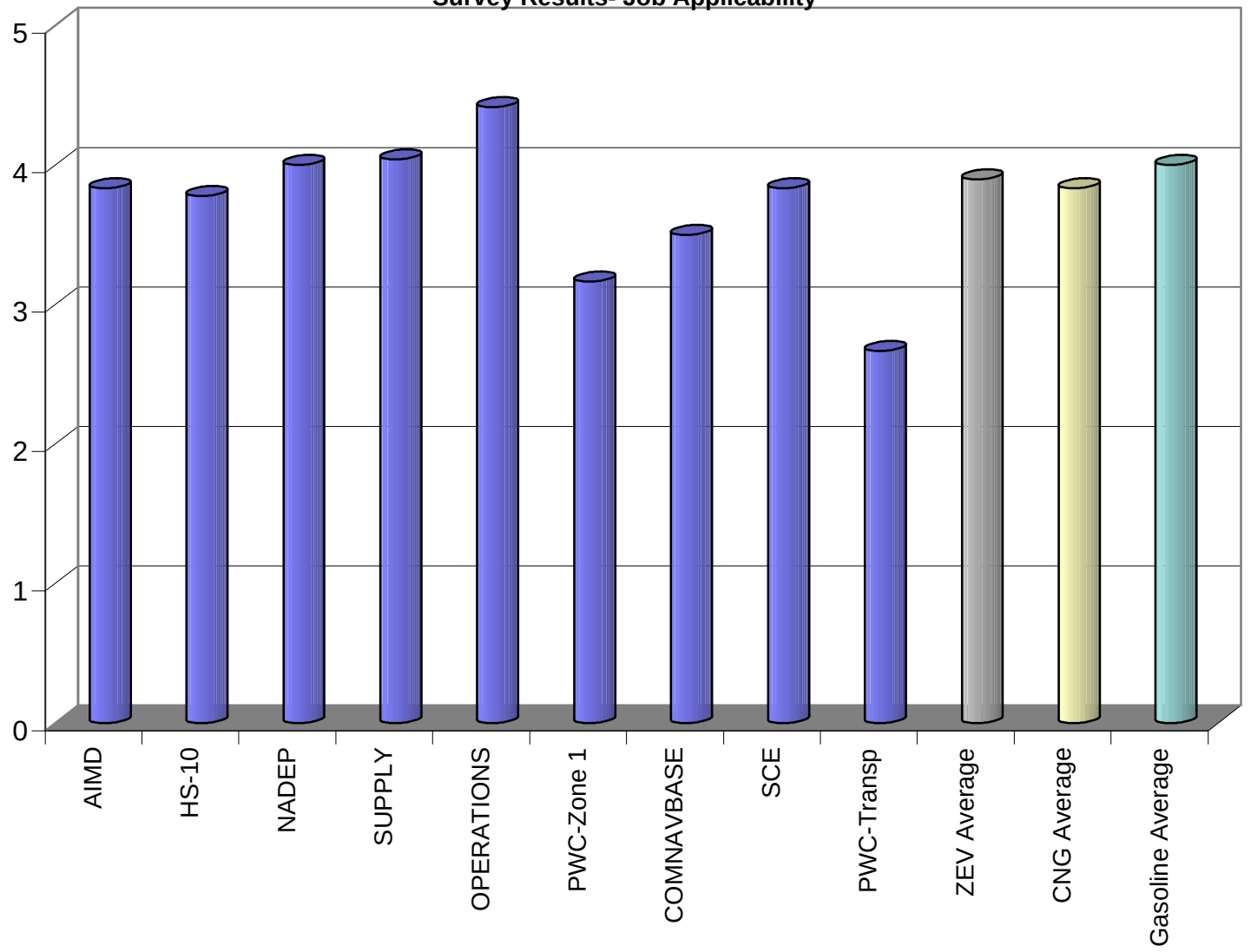


Figure C-3
Survey Results - Interior Gauges and Comfort

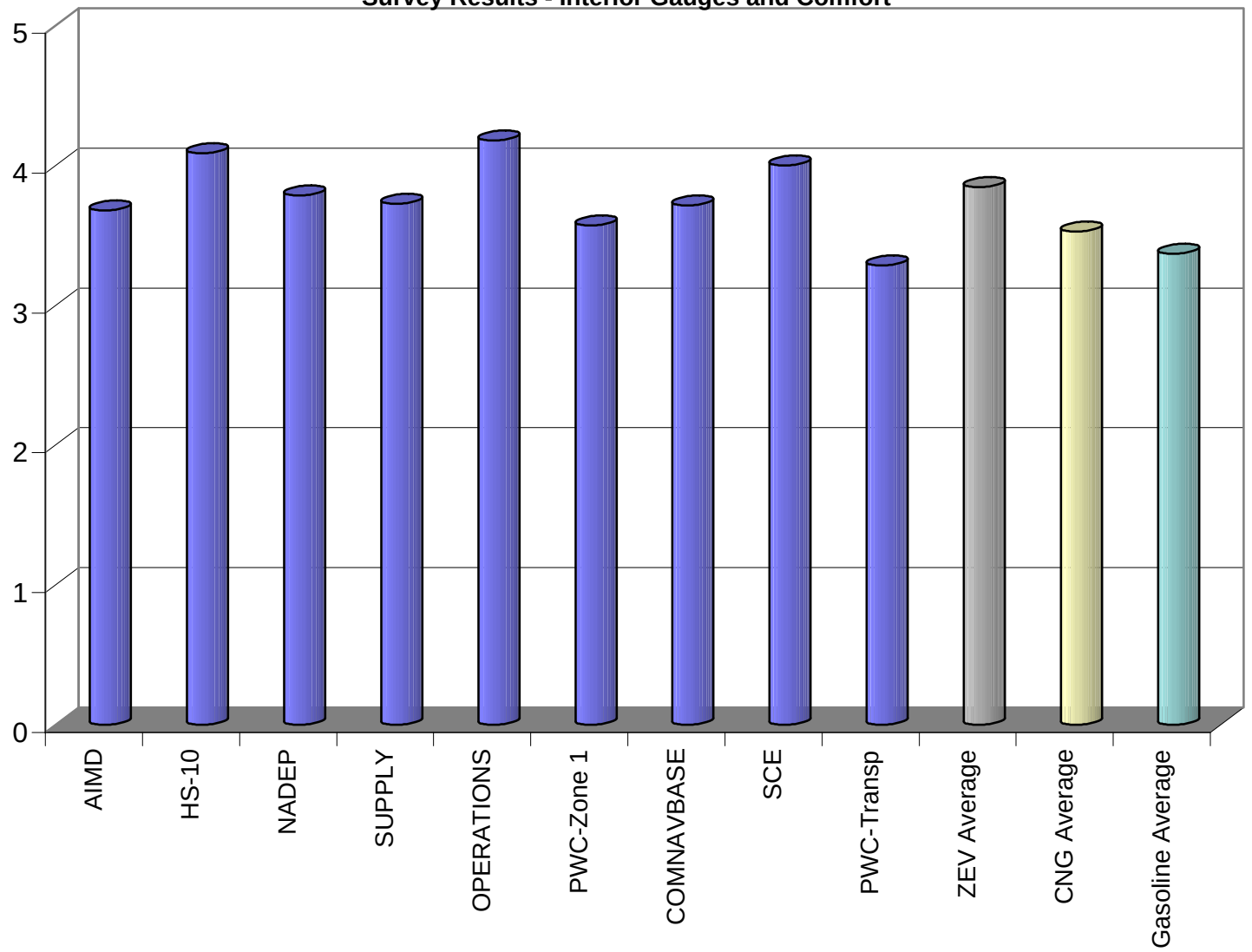


Figure C-4
Survey Results - Charging

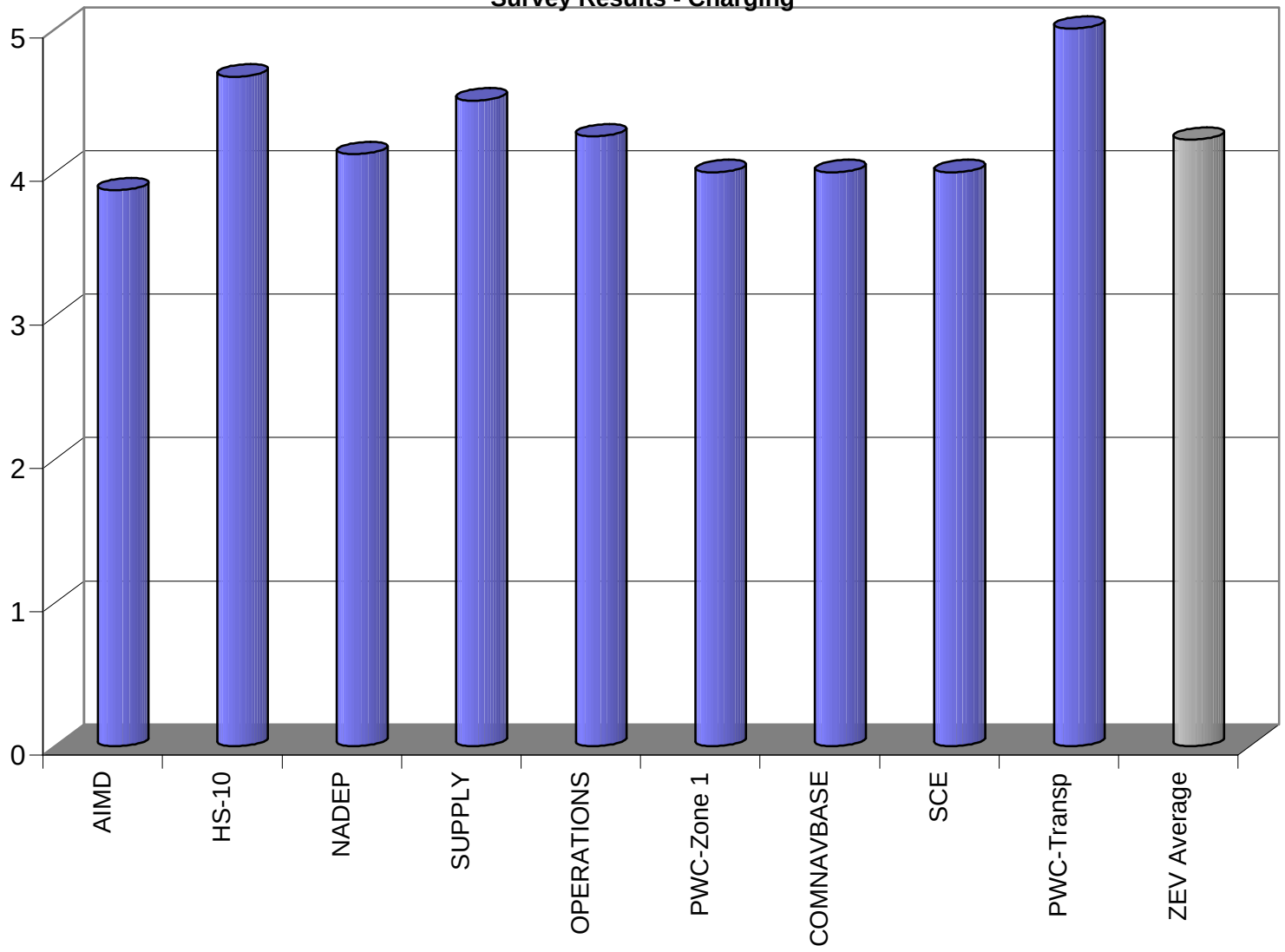


Table C-1
Maintenance Record Review Summary

Vehicle ID	Date	Problem	Repairs	Cost
AIMD 94-62890 (V8191050)	**2/11/98**	• Campaign (replaced axles) • Coolant reserve empty and not sealing properly • Heater not working	• Campaign (replaced axles) • Filled up coolant • Heater working to specifications • Cleared codes	$871.87
	4/20/98	• Battery light on • Service light on • Wait light on for 3-5 minutes • Cycling ignition • Battery modules out of balance	• Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well. • Cleared codes	$192.39
	10/21/98	• Brakes • A/C - Heating problems • Miscellaneous electrical		$3,413.41
NADEP 94-62896 (V8199171)	**12/9/97**	• Will not take charge (Only charges to ½) • Coolant level low	• Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well. • Filled up coolant	$187.50
	4/1/98	• Campaign (replaced axles) • Charger inhibit code, battery life light on, service soon light on at times • Coolant low and leaking	• Campaign (replaced axles) • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well. • Filled up coolant	$856.13
	9/23/98	• GM updates as necessary		$1,505.43
PWC Zone 1 94-62897 (V8198651)	**9/10/97**	• Brake and Check Engine lights on	•	$426.00
	2/26/98	• Campaign (replaced axles)	• Campaign (replaced axles)	$761.55
	5/14/98	• Will not take charge • Warning light on • Battery modules #4 and #8 low • Voltage below specifications	• Reprogrammed DMCM, • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$231.32
	8/4/98	• Will not move • APCM not charging auxiliary battery • No output at APCM	• Charge auxiliary battery • Load test hold at 10.2 volts at 260 amps • Replaced APCM • Charges battery pack	$1,846.04
SCE EP1 94-62892 (V8192876)	**9/10/97**	• Engine will not crank	• Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$453.60
	11/17/97	• Engine will not crank • Electrolyte reservoir empty, bad seal, seal avail 1 Dec. (towing to Burbon)	• Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$156.20
	2/11/98	• Campaign (replaced axles) • Coolant pump not running (internally open) • Will not take charge • Charge receptacle overheat	• Campaign (replaced axles) • Replaced coolant pump and buffer, • Charged batteries to full. Road tested well.	$1,165.37

Table C-1
Maintenance Record Review Summary (continued)

	8/4/98	• Coolant rec. bottle empty from leaking seal • Will not take charge • Would not move with full charge	• Filled up coolant • Reprogrammed BPCM per Bulletin # 86 69 09 • Reprogrammed 10 MCM per Bulletin # 76 6406 after vehicle would not move with full charge. • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$580.05
	9/24/98	• Cooling system • Miscellaneous electrical • A/C - Heating problems		$1,063.84
SCE EP2 94-62893 (V8193021)	**9/10/97**	• Power steering inoperable	• Towed to Gunderson	$53.60
	2/6/98	• Campaign 97060 (replaced axles) • Will not take charge	• Campaign 97060 (replaced axles) • Replaced charge receptacle	$3,238.68
	7/10/98	• Power steering inoperable • Will not take charge	• Replaced PSCM and power steering pump • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$1,234.51
	9/24/98	• Miscellaneous electrical • A/C - Heating problems		$1,176.03
SUPPLY 94-62894 (V8192839)	**9/24/97**	• Power steering inoperable	• Towed to Gunderson	$267.50
	10/22/97	• Power steering inoperable • Battery problems	• Replaced power steering module	$1,193.84
	6/30/98	• Campaign (replaced axles) • Will not charge	• Campaign (replaced axles) • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$712.37
	8/4/98	• Will not move, battery appears charged	• Truck needs to be charged before it gets low or same problem will occur • Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$303.73
	9/9/98	• Battery light on • Necessary to cycle key to get prop • No/low power (<25mph) • Engine light on • Battery 12 very low	• Replaced battery module 12	$1,641.75

Table C-1
Maintenance Record Review Summary (continued)

OPERATIONS 94-62891 (V8194074)	**6/3/98**	• Campaign (replaced axles)	• Campaign (replaced axles)	$712.37
	9/23/98	• Power steering inoperable	• Replaced PSCM and plot pump bled system • Retrofits	$2,935.37
	10/22/98	• Shudders and rough acceleration from stops • Amps fluctuate abnormally up and down only when shuddering	• Tested system, no codes • Problem inside PIM, replaced, reprogrammed	$298.94
COMNAVBASE 94-62898 (V8190492)	**10/8/97**	• Not holding charge	• Customer concern not duplicated	$143.62
	9/16/98	• Campaign (replaced axles) • Truck won't start • Aux. battery dead, charged	• Campaign (replaced axles), customer has other parts • Charged aux. battery	$1,989.87
	12/21/98	• Miscellaneous electrical		$275.74
PWC TRANSP 94-61120 (V8182690)	**2/6/98**	• Campaign (replaced axles) • Battery light on, limp mode • Battery module #12 low	• Campaign (replaced axles) • Drained battery. Batteries were exercised to rebalance the modules. Charged batteries to full. Road tested well.	$931.55
	3/10/98	• Limp mode (<25 mph) • Battery light on • Battery #12 low	• Charged batteries to full. Road tested well.	$807.94
	5/5/98	• Will not take charge • Battery #12 low	• Replaced Battery #12	$239.73
	11/18/98	• Will not take charge • Needs updates	• Reprogrammed	$1,243.54
HS-10 94-62895 (V8195785)	**9/10/97**	• Will not crank		$666.94
	11/17/97	• Will not crank • P/S leak		$156.20
	2/26/98	• Campaign (replaced axles)	• Campaign (replaced axles)	$761.55
	4/1/98	• See back mil 1499		$190.94
	5/14/98	• Towed to shop • Service soon light on • Will not take charge	• Replaced battery (battery module #18) • Charged batteries to full. • Reprogrammed BPCM • Road tested well.	$372.70

Table C-1
Maintenance Record Review Summary (continued)

	8/20/98	• Damaged bumper • Service soon light on • Hard to charge	• Belly pan removed, inspected, okay	$31.50
	8/21/98	• Service soon light on • Hard to charge	• Replaced coolant reservoir per bulletin 86 62 09 (low and leaking)	$283.60
	8/26/98	• Body work	• Body work	$810.06
	9/22/98	• Updates per Chevy guidelines	• Reprogrammed BPCM w/updated software • Replaced clamp & cap • Replaced HTCM and elbow • Charged batteries to full	$977.79

Notes:

A/C	Air conditioning
APCM	Accessory power control module
BPCM	Batter pack control module
DMCM	Drive motor control module
HTCM	Heat and thermal control module
MCM	Motor control module
PIM	Power inverter module
PSCM	Power steering control module
P/S	Power steering